Report

Final Report

Economic Assessment of the Zero Waste Plan for Scotland

An evaluation of the financial and environmental consequences for Scotland of meeting the 'Zero Waste Plan' targets.

Project Code: MKN047
Research date: February 2011 – May 2011 **Date:** July 2011

Zero Waste Scotland works with businesses, individuals, communities and local authorities to help them reduce waste, recycle more and use resources sustainably.

Find out more at www.zerowastescotland.org.uk

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Executive summary

This work quantifies the costs and benefits of introducing the Zero Waste Plan Regulations in Scotland (the ZWP Scenario) against a Business as Usual (BaU) Scenario. Modelling was for the years 2010-2025. The Scenarios were as follows:

- **Business as Usual (BaU): policy environment includes only those policies which have already been announced (such as the escalating landfill tax);**
    - a) Landfill tax has been modelled to reach £80 per tonne in 2014/15, remaining constant, in real terms, thereafter;

      It was requested that the scenario should be developed so as to meet EU requirements for a reduction in landfilling of biodegradable municipal waste (BMW), and EU requirements for recycling, which are as follows[1]:

    - b) A maximum of 1.8 million tonnes of BMW sent to landfill in Scotland by 2013;
    - c) A maximum of 1.26 million tonnes of BMW sent to landfill in Scotland by 2020;[2]
    - d) In line with the revised Waste Framework Directive;
        - i. The preparation for re-use and recycling of 50% by weight of waste materials (paper, metal, plastic and glass) from household and similar wastes by 2020:
        - ii. 70% recycling / reuse, preparation for re-use and other recovery of C&D waste by 2020;

- **Zero Waste Plan:[3]**
    - e) Zero Waste Plan target of 70% recycling, on the basis of the carbon metric, is met for all waste streams (individually) by 2025;[4]
    - f) A maximum of 5% of waste is sent to landfill by 2025;
    - g) The following regulations are introduced (note that the form of these is not yet finalised so some description of our assumptions regarding their form is given below):
        - iii. A requirement to source segregate and separately collect key dry recyclable materials (paper, card, glass, metals, plastics and textiles) and food waste due to the environmental benefits of managing biowastes separately;
        - iv. A ban on mixing separately collected recyclable materials is implemented;
        - v. A ban on sending key recyclable materials to landfill is put in place;
        - vi. A restriction on inputs to energy from waste (EfW) facilities is implemented;
        - vii. A ban on waste disposal to landfill is implemented.[5]

[1] These requirements arise from Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste (Official Journal L 182 , 16/07/1999 pp 0001 – 0019) and Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Official Journal L312/3, 22/11/2008, pp.3-30). The WFD requests (Article 22) that Member States take measures to 'encourage' separate collection of biowaste, and its treatment. The Landfill Tax and the systems of FITs might reasonably be viewed as measures which do, indeed, encourage this, but since we could not be expected to model a 'level of encouragement', we have not done so.

[2] Note that these figures take into account the revised definition of municipal waste which the UK has been requested to adopt by the European Commission.

[3] See Scottish Government (2011) Regulations to Deliver Zero Waste: A Consultation on the proposed Zero Waste (Scotland) Regulations 2011, available at: http://www.scotland.gov.uk/Publications/2011/02/09135833/0

[4] Zero Waste Scotland (2011) The Scottish Carbon Metric, available at: http://www.wrap.org.uk/downloads/Technical_Report_FINAL.6fc98afe.10581.pdf

[5] The 'ban' is assumed unlikely to be an outright ban, rather a restriction on what can be landfilled and under what circumstances.

We examined the effects of switching from BaU to ZWP under five different assumptions. These related to:

1. Whether the costs of non-landfill treatment for residual waste are likely to be the same, or lower, or higher than the costs of landfill (including tax) in future. We called these the Cent. T, Low T and High T cases, respectively; and
2. The extent to which, under BaU, the commercial waste recycling market was responding 'rationally' to the avoided costs of residual waste treatment / disposal at the time. We modelled cases where the market was moderately rational, weakly rational and highly rational. We called these Central R, Low R and High R, respectively.

The Central Case for the study is that where we assume the Central case for both the costs of residual waste treatment, and the rationality of the commercial waste market, prevail. We then tested, one at a time, the impact of increasing, then decreasing the rationality assumption, and increasing, then decreasing the cost of non-landfill residual waste treatment, as illustrated in Table 1, which shows which pairs of assumptions were modelled.

Table E1: Sets of Paired Assumptions Used in Modelling Switch from BaU to ZWP

	Low T	**Cent T**	**High T**
Low R		Cent T, Low R	
Cent R	Low T, Cent R	Cent T, Cent R **Central Case**	High T, Cent R
High R		Cent T, High R	

In this Central Case, it is assumed that the requirement to sort recyclables and food under the ZWP is introduced in 2013, and that the ban on waste to landfill – assumed to be implemented through a requirement to pre-treat waste to ensure it loses the majority of its ability to generate methane – is introduced in 2017. The significance of the timing of the measures is discussed further below and in more detail in the Main Report. The effects of changes in timing were considered only for the Central Case.

Details of how the modelling was carried out can be found in Section 4 of the Main Report and in the associated Appendices. Essentially, however forward looking trajectories were developed for the two Scenarios, and the costs and benefits of moving from one (BaU) to the other (ZWP) were assessed.

It is worth emphasising that the data available has been of relatively poor quality and it has been difficult to generate a dataset which exhibits consistency with various sources available.. This does mean that the results need to be taken as indicative in their magnitude, not least because of uncertainties in the quantities of waste in the C&I and C&D sectors..

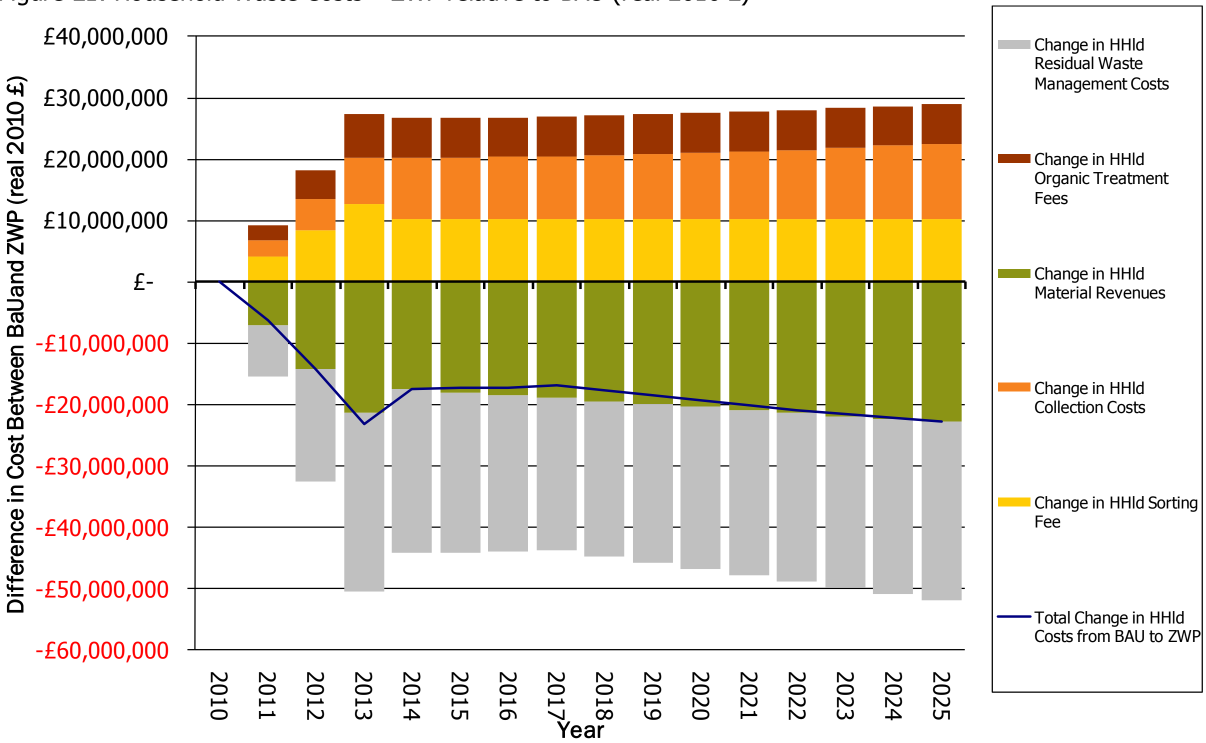
Financial Costs

Household waste

The financial costs of the switch from BaU to ZWP for household waste are shown in Figure E1 with Table E2 displaying the raw data on costs for the two Scenarios. The pattern indicates that in early years, the effect of the requirement to sort dry recyclables and food reduces costs to the authorities. This is because under BaU, local authorities are assumed not to be recycling and composting at a level which would appear to be justified by the prevailing 'avoided cost of disposal' (represented, in most local authorities, by the avoided costs of collecting and landfilling refuse).

In the year 2014, the costs increase as the effect of the requirement to sort waste is assumed to have been felt in full, but landfill tax is still rising. In the years from 2014 to 2017, however, the difference in costs remains broadly constant as residual waste management is switched away from landfill into treatments with the same cost. There is a marginal upturn in cost reflecting the assumed increase in household numbers in this period, and the effect this has on household waste collection costs.

Figure E1: Household Waste Costs – ZWP relative to BAU (real 2010 £)



Note: Negative numbers imply negative costs (i.e. savings) in the above diagram

The ZWP implies a programme of investment in infrastructure. For household waste management, we estimate that whilst under BaU, investment of around £140 million would be required in capital equipment, this rises to £490 million under the ZWP. Whether this capital investment is funded by local authority capital or revenue spending will depend upon the financing structure and the approach to procurement used by the local authorities.

Table E2: Costs for Management of Household Waste under BaU and ZWP (real 2010 £, millions)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BaU SCENARIO																
Total HHld Collection Costs	£147	£152	£158	£164	£170	£170	£171	£173	£174	£177	£179	£183	£186	£191	£195	£200
Total HHld Material Revenues	-£37	-£42	-£46	-£50	-£54	-£54	-£54	-£54	-£54	-£54	-£54	-£54	-£54	-£54	-£54	-£54
Total HHld Organic Treatment Fees	£12	£13	£14	£15	£16	£16	£16	£16	£16	£16	£16	£16	£16	£16	£16	£16
Total HHld Residual Waste Management Costs	£111	£116	£121	£122	£124	£124	£124	£124	£124	£124	£124	£124	£124	£124	£124	£124
Total HHld Sorting Fee	£23	£26	£28	£31	£33	£33	£33	£33	£33	£33	£33	£33	£33	£33	£33	£33
Total HHld Costs	£256	£266	£276	£282	£289	£290	£290	£292	£294	£296	£299	£302	£306	£310	£314	£319
ZWP SCENARIO																
Total HHld Collection Costs	£147	£155	£163	£171	£180	£180	£181	£183	£185	£187	£190	£194	£198	£202	£207	£212
Total HHld Material Revenues	-£37	-£49	-£60	-£71	-£71	-£72	-£72	-£73	-£73	-£74	-£74	-£75	-£75	-£76	-£76	-£77
Total HHld Organic Treatment Fees	£12	£15	£19	£22	£22	£22	£22	£22	£22	£22	£22	£22	£22	£22	£22	£22
Total HHld Residual Waste Management Costs	£111	£108	£103	£93	£98	£98	£99	£100	£99	£99	£98	£98	£97	£96	£96	£95
Total HHld Sorting Fee	£23	£30	£37	£43	£43	£43	£43	£43	£43	£43	£43	£43	£43	£43	£43	£43
Total HHld Costs	£256	£260	£262	£259	£272	£272	£273	£275	£276	£277	£279	£282	£285	£288	£292	£296
Additional Cost of ZWP	£0	-£6	-£14	-£23	-£17	-£17	-£17	-£17	-£18	-£19	-£19	-£20	-£21	-£22	-£22	-£23

Commercial and Industrial (C&I) Waste
The picture regarding C&I is rather finely balanced (see Figure E2). The additional costs of separate collection of waste for recycling are offset by the savings on residual waste management (i.e. treatment and disposal). The raw data are shown in Table E3.

Figure E2: C&I Waste Costs - ZWP relative to BAU (real 2010 £)

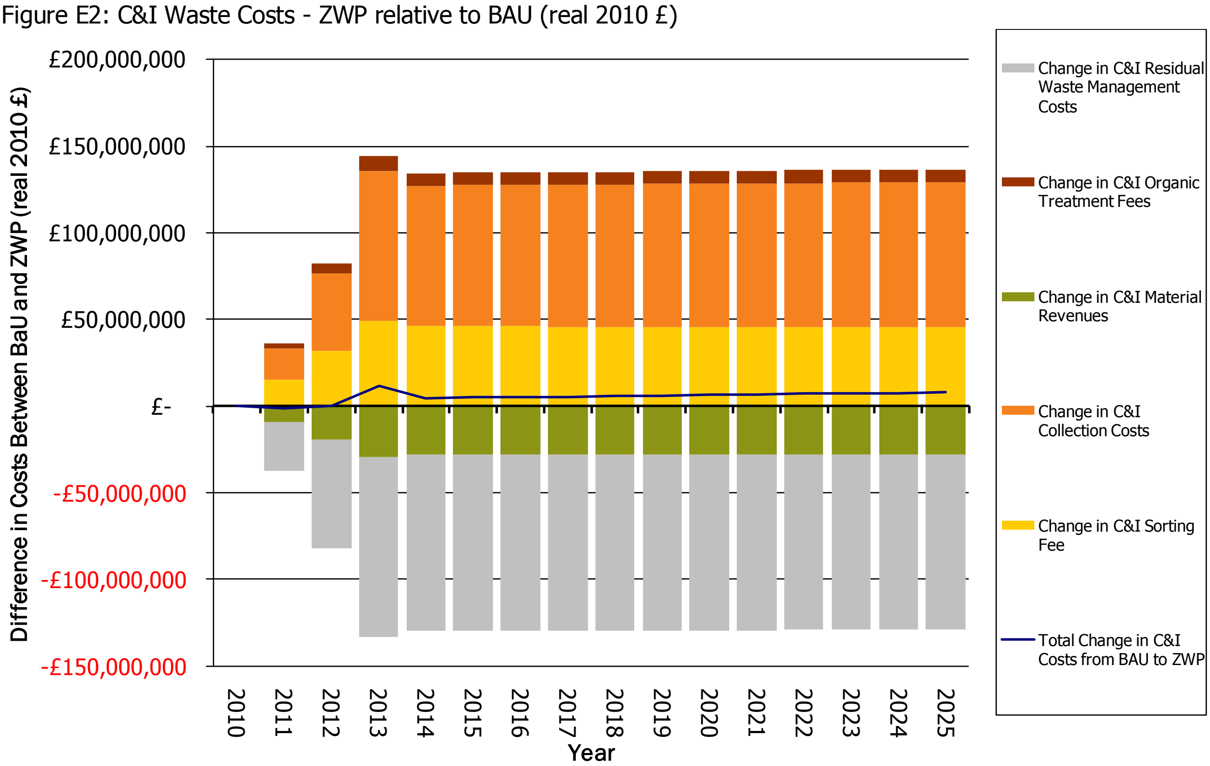


Table E3: Costs for Management of Commercial and Industrial Waste under BaU and ZWP (real 2010 £, millions)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BaU SCENARIO																
Change in C&I Collection Costs	£0	£10	£24	£43	£57	£55	£54	£53	£52	£51	£50	£49	£48	£47	£46	£45
Change in C&I Material Revenues	£0	-£3	-£8	-£14	-£18	-£17	-£17	-£16	-£16	-£15	-£14	-£14	-£13	-£13	-£12	-£12
Change in C&I Organic Treatment Fees	£0	£2	£4	£6	£9	£8	£8	£8	£8	£8	£8	£8	£8	£8	£8	£8
Change in C&I Residual Waste Management Costs	£0	£12	£26	£36	£41	£40	£40	£40	£39	£39	£38	£38	£38	£37	£37	£37
Change in C&I Sorting Fee	£0	£5	£10	£18	£23	£23	£23	£22	£22	£22	£22	£22	£21	£21	£21	£21
Total Change in C&I Costs From 2010	£0	£25	£57	£89	£111	£110	£109	£107	£106	£105	£104	£103	£101	£100	£99	£98
ZWP SCENARIO																
Change in C&I Collection Costs	£0	£28	£69	£130	£138	£137	£136	£135	£134	£133	£132	£132	£131	£130	£129	£128
Change in C&I Material Revenues	£0	-£13	-£27	-£43	-£46	-£45	-£45	-£44	-£43	-£43	-£42	-£42	-£41	-£40	-£40	-£39
Change in C&I Organic Treatment Fees	£0	£5	£10	£15	£16	£16	£16	£16	£16	£15	£15	£15	£15	£15	£15	£15
Change in C&I Residual Waste Management Costs	£0	-£16	-£36	-£68	-£61	-£61	-£62	-£62	-£62	-£63	-£63	-£63	-£64	-£64	-£64	-£65
Change in C&I Sorting Fee	£0	£20	£42	£67	£69	£69	£69	£68	£68	£68	£68	£68	£67	£67	£67	£67
Total Change in C&I Costs From 2010	£0	£24	£57	£101	£116	£115	£114	£113	£112	£111	£110	£109	£109	£108	£107	£106
Additional Cost of ZWP	£0	-£1	£0	£12	£5	£5	£5	£6	£6	£6	£7	£7	£7	£7	£8	£8

All Waste Streams

The situation for all waste streams (i.e. household, commercial and industrial, construction and demolition waste streams) is shown in Figure E3 and E4. Figure E3 demonstrates that the move to ZWP will not impose additional financial costs under the assumptions we have made for the Central Case. There is a net financial saving of the order £18 million per annum made, amounting to £178 million in net present value terms over the period 2011-2025

Figure E3: All Waste Streams Costs - ZWP relative to BAU (real 2010 £)

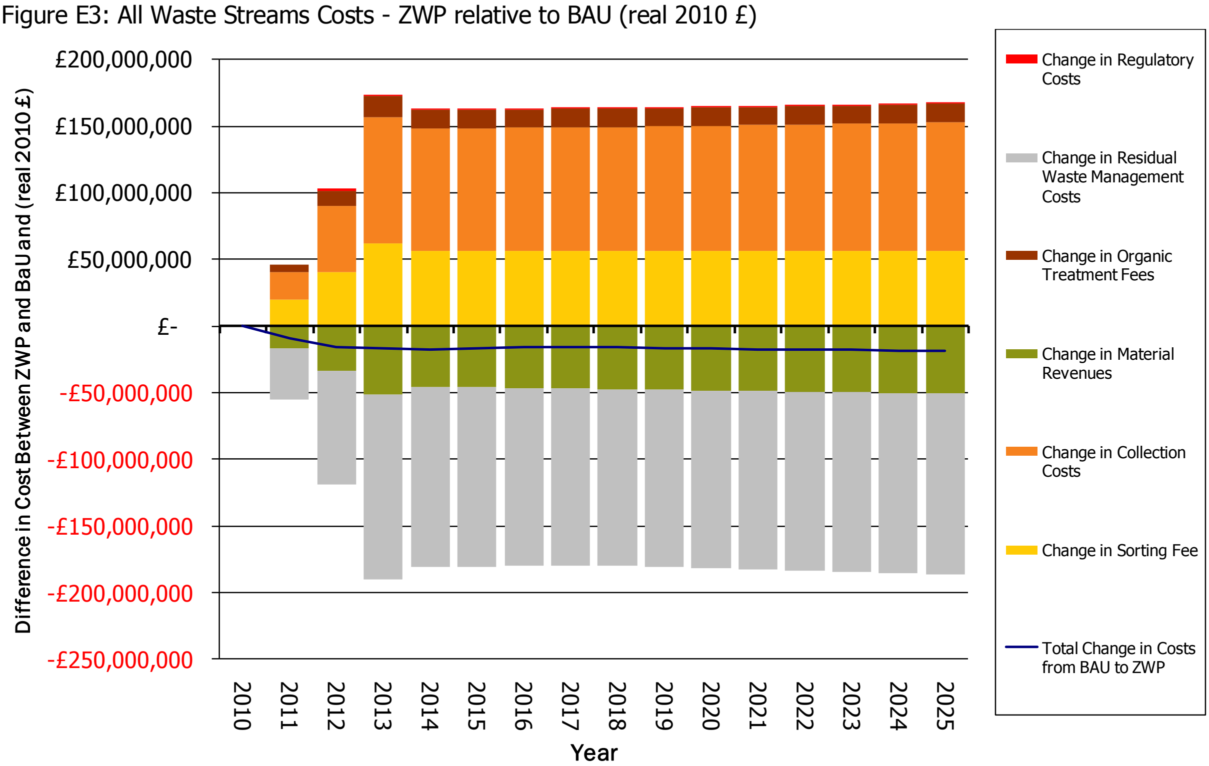


Figure E4 indicates that under the assumptions made in the Central Case, savings are made overall across all waste streams. However, they are most significant for the household waste sector. Part of the reason for this is that the C&I waste and C&D waste sectors are expected to respond more strongly to the landfill tax over the coming years. Even so, for these waste streams too, there are likely to be additional opportunities for cost saving, if only because the availability and take up of services would be enhanced under the requirement to sort.

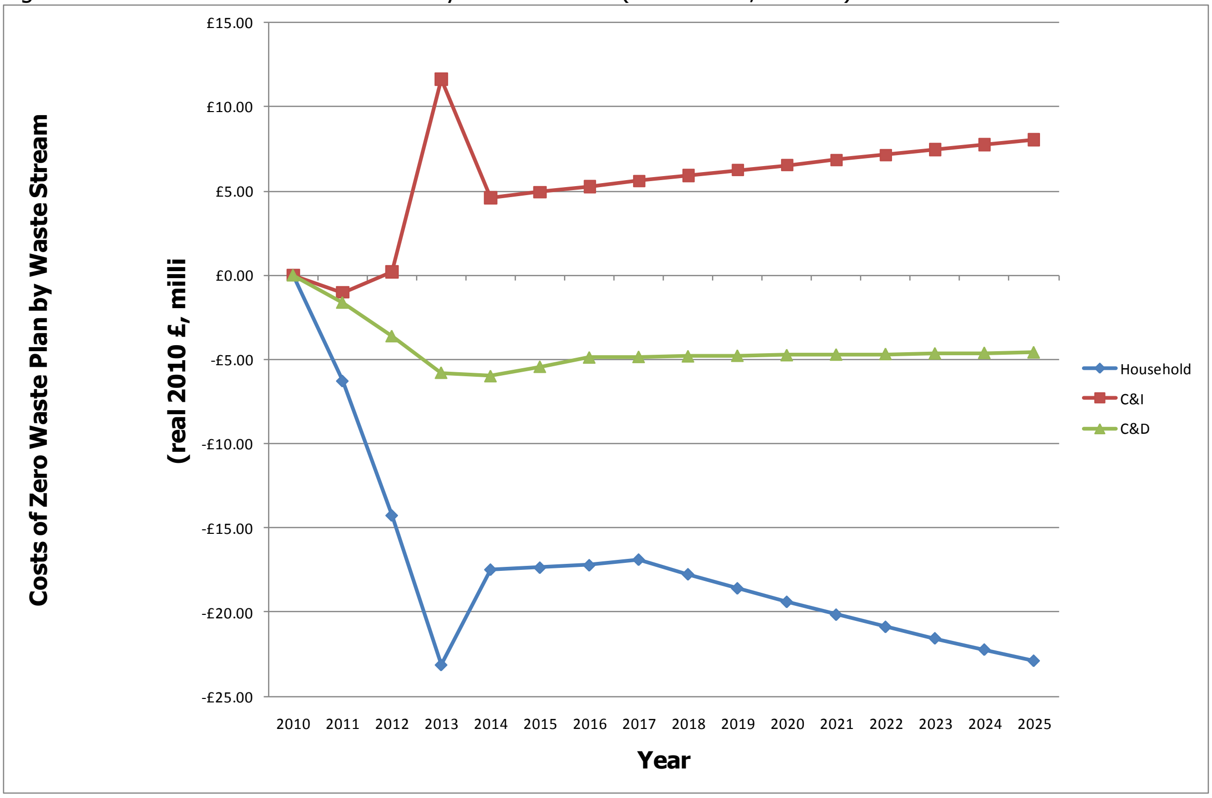
The projected changes in cost are sensitive to some crucial model parameters, notably:

1. The extent to which the C&I waste collection market is 'rational' from an economic perspective; and
2. The degree to which the costs of alternative residual waste treatments (to landfill) are greater than those of landfill, inclusive of tax at £80 in nominal terms, in the future.

The significance of these is explored further in Section 7 of the Main Report. Note that this final point also makes the rate of inflation a potentially influential variable in the analysis.

Our modelling suggests that over the period examined, the ZWP implies the need for around £1.16 billion in terms of capital investment. This is an increase of around £472 million relative to BaU. For local authorities, the effect is to increase the requirement for capital infrastructure, or access to such infrastructure (local authorities do not need to fund the capital investment directly, and may use revenue spend to access / support the investment in facilities) from around £140 million to £490 million over the fifteen year period.

Figure E4: Costs of ZWP relative to BAU by Waste Stream (real 2010 £, millions)



Environmental Impacts
The preceding results have examined only the financial costs. We also undertook an analysis of the environmental implications for the switch from BaU to ZWP. Broadly speaking, these environmental impacts include:

- Changes in the level of emissions of greenhouse gases (GHGs)
- Changes in the level of emissions of other air pollutants (oxides of nitrogen (NOx), oxides of sulphur (SOx), particulate matter (PM), dioxins and some heavy metals), which have consequences for human health; and
- Changes that arise from the application of compost / digestate to land.

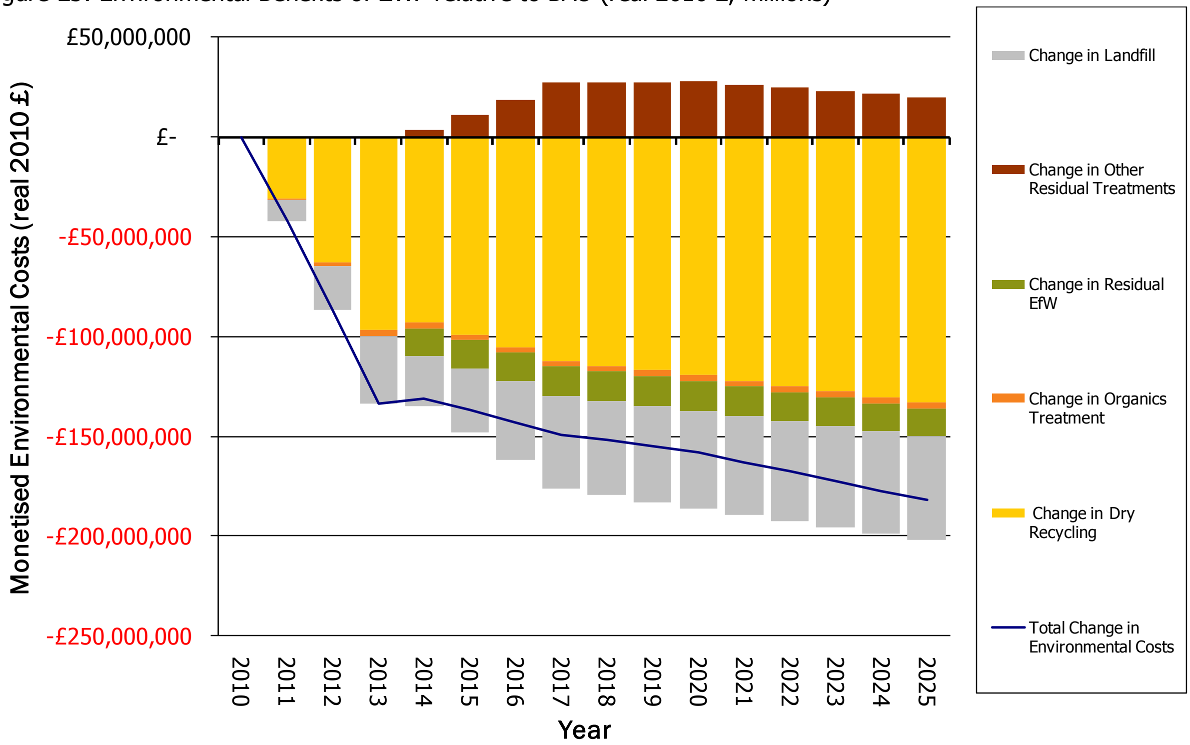
The analysis includes the changes in emissions associated with avoiding the use of primary materials, or avoiding the generation of energy through the use of fossil fuels, which the processes being encouraged by the ZWP are expected to deliver (further detail is given at Section 0 of the Main Report).

Figure E5 indicates that the monetised benefits exceed £180 million per annum following full implementation of the ZWP as envisaged. It also shows that by far the greatest benefit comes from the additional recycling of dry recyclables (around £135 million, or close to 75% of the total benefit). The next largest contribution comes from the avoidance of landfilling. The next largest benefit is associated with the treatment of organic wastes (around £52 million in 2025). There is some overlap between the benefits associated with the avoidance of landfilling and those with the treatment of organic waste. When material is separately collected for biological treatment, landfilling is avoided, and the benefits of biological treatment are secured. Hence, collecting biowaste contributes much to, but does not account for all, the benefits of avoiding landfilling because of the implied removal of biodegradable material from landfill.

The switch into alternative residual waste treatments does incur some environmental costs, but these are typically lower than those avoided in the switch away from landfilling. The alternative treatments generate costs of around £20 million in 2025 (note that these costs are assumed to be related to a mix of residual waste treatments, not to any specific process).

The monetised environmental benefits are presented separately from the purely financial costs. Adding them together would create double counting as is set out in the main body of the report.

Figure E5: Environmental Benefits of ZWP relative to BAU (real 2010 £, millions)



Sensitivity Analysis – Timing of the Regulations
In order to understand the potential consequences of moving the implementation dates for these regulations, we examined the overall costs and benefits of the move to ZWP under the following scenarios:

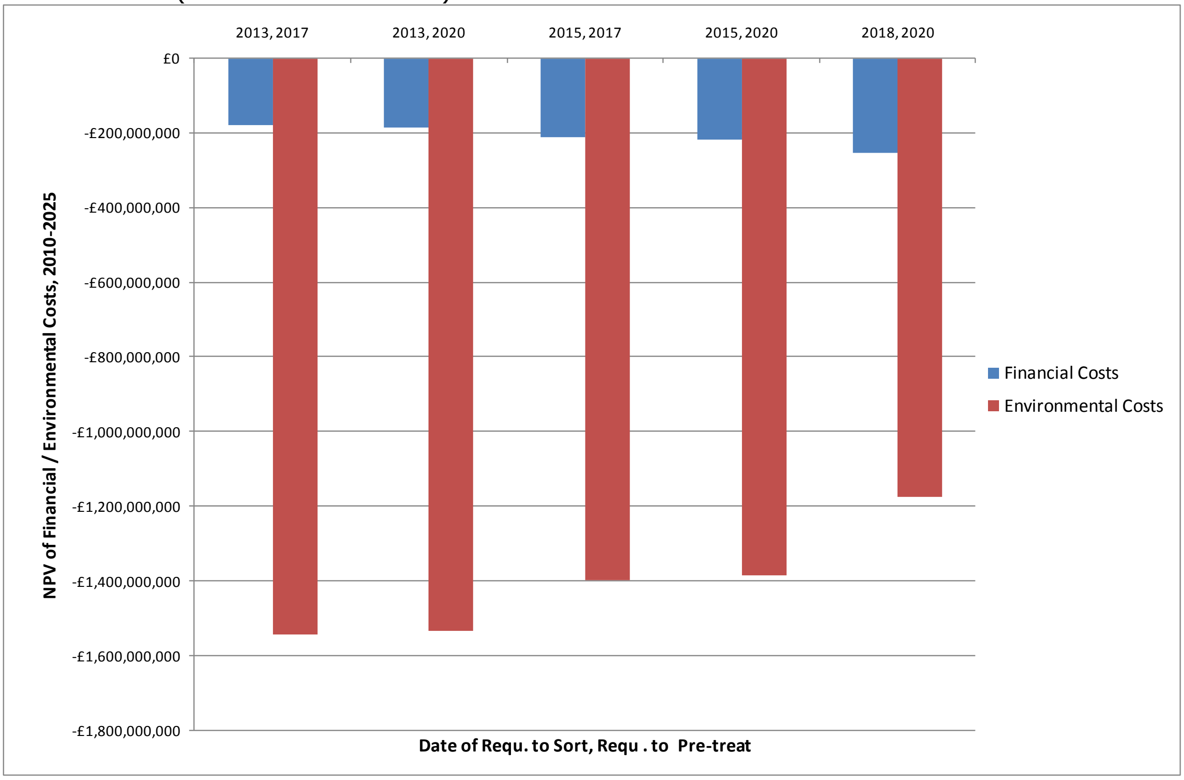
1. Requirement to Sort in 2013, Requirement to pre-treat in 2017;
2. Requirement to Sort in 2013, Requirement to pre-treat in 2020;
3. Requirement to Sort in 2015, Requirement to pre-treat in 2017;
4. Requirement to Sort in 2015, Requirement to pre-treat in 2020; and
5. Requirement to Sort in 2018, Requirement to pre-treat in 2020.

Figure E6 and Table E3 summarises the Net Present Value of the flow of net costs to society. The following observations can be made regarding the changes in timing:

1. The value of the environmental benefits generated by the ZWP declines as the requirement to sort moves back in time;
2. However, the financial savings generated by the ZWP increase as the requirement to sort moves back in time, but this increased saving is smaller than the extent of the reduction in environmental benefits;
3. The effect of moving the requirement to pre-treat back in time barely has any impact. It increases savings generated by the ZWP marginally but it also reduces environmental benefits (the effects seem small, and more or less balanced); and
4. The effect on financial costs of the changes is less significant than the effect on environmental costs.

The suggestion is that the most important factor is the timing of the requirement to sort. In general, the financial savings are lower and the environmental benefits are higher as the requirement to sort is moved forward.

Figure E6: Financial and Environmental Costs of Different Timing Options for Introducing Requirement to Sort and Requirement to Pre-treat Waste (Net Present Value terms)



Note- positive figures represent costs/disbenefits, negative figures represent savings / benefits. Please note that the net present value is calculated from figures in which capital costs are already annualised.

Table E3: Net Present Value of the Change in Financial and Environmental Costs (from BAU to ZWP), 2010-2025, for Variants on Timing of Regulations (central case in italics)

Scenario	**NPV of Financial Costs (2010-2025)**	**NPV of Environmental Costs (2010-2025)**
Requirement to Sort in 2013, Requirement to pre-treat in 2017	*-£178 million*	*-£1,544 million*
Requirement to Sort in 2013, Requirement to pre-treat in 2020	-£186 million	-£1,533 million
Requirement to Sort in 2015, Requirement to pre-treat in 2017	-£211 million	-£1,398 million
Requirement to Sort in 2015, Requirement to pre-treat in 2020	-£218 million	-£1,387 million
Requirement to Sort in 2018, Requirement to pre-treat in 2020	-£255 million	-£1,177 million

Note: negative figures represent savings/benefits

Additional Comments

The following comments are offered concerning issues faced in the project and the desirability of additional investigations:

1. There are some areas of the analysis which would merit further investigation. Knowing what we do about the available data and information, it would seem sensible to consider some further analysis – including survey work - of the commercial waste collection market in Scotland itself;

2. Regarding household waste, the modelling is 'top down' at present. Different authorities have different plans, and will likely take different approaches to achieving their targets. The study has sought to reflect, as far as possible, what local authorities may do, based upon information regarding their current collection schemes. Without deeper knowledge of their likely approach, however, the results remain indicative of likely costs. It should also be noted that the modelling represents efficiently functioning systems. Our extensive experience in England suggests there may be existing inefficiencies that can be squeezed out so as to limit any increases in collection costs implied by the ZWP; and
3. It would be interesting to conduct the analysis in a more conventional cost-benefit framework, enabling the environmental and financial costs to be added together. The approach taken here to assessing the financial costs, is designed to represent the actual costs that actors will face in the market, but thereby makes the combination of environmental and financial benefits problematic, from a methodological point of view, in the current study.

Contents

Glossary

Anaerobic Digestion (AD) – Anaerobic digestion is a biological process in which microorganisms break down biodegradable material, in this case food waste, in the absence of oxygen.

Collection Costs – Includes vehicles, staff, fuel, insurance, other overheads and financing, increase in local authority promotion, and also the costs for additional Household Waste and Recycling Centres.

In-Vessel Composting (IVC) – In-vessel composting uses enclosed reactors windrows to treat green waste, i.e. a mix of food and garden wastes.

Kerbside Sort Collection (C&I) – This term applies to the collection of recyclable materials that are separated at source onto a vehicle for businesses in the commercial and industrial sector, similar to a household kerbside sort scheme.

Local Authority Collected (LAC) Waste – Waste collected by or on behalf of local authorities, including household, trade and other waste. This term has been chosen since the definition of municipal waste has effectively changed and now includes some C&I waste not collected by local authorities.

Open Air Windrow (OAW) – Windrow composting is used for processing garden waste in an open air environment where the material can break down in the presence of oxygen.

Pre-treatment – The term 'pre-treatment' is used to denote forms of treating residual waste other than landfill which are consistent with what is expected to emerge under the ZWP regulations. This has not been completely defined as yet. However, it could include forms of mechanical biological treatment, and forms of thermal treatment where the residual waste has been subjected to some form of sorting process prior to its being thermally treated.

Abbreviations

AD – Anaerobic Digestion

BaU – Business as Usual (Scenario)

BERR – (Department for) Business, Enterprise and Regulatory Reform

BIS – (Department for) Business, Innovation and Skills

C&I – Commercial and Industrial (waste)

C&D – Construction and Demolition (waste)

Capex – Capital expenditure

CCL – Climate Change Levy

CHP – Combined Heat and Power

CHPQA – CHP Quality Assurance Programme

CIMS – Collections, Infrastructure and Markets Sector (plan)

DECC – Department of Energy and Climate Change

EfW – Energy from Waste

HWRC – Household Waste and Recycling Centre

IVC – In-Vessel Composting

LAC – Local Authority Collected (waste)

MPG – Miles per gallon

MRF – Material recycling facility

MWh – Megawatt Hours

Opex – Operational expenditure

OAW – Open Air Windrow

ROC – Renewable Obligation Certificate

RCV – Refuse Collection Vehicle

SEPA – Scottish Environment Protection Agency

WRAP – Waste & Resources Action Programme

ZWP – Zero Waste Plan

ZWS – Zero Waste Scotland

1. Introduction

Eunomia Research & Consulting is pleased to present this Final Report to Zero Waste Scotland (ZWS) concerning the costs and benefits of implementing the Scottish Government's Zero Waste Plan (ZWP). The Scottish Government has set out its stall to introduce forward thinking waste management policies in the years ahead. These can be expected to deliver significant environmental benefits in future. Of some interest is the balance of the financial consequences of introducing the measures, and the environmental impacts associated with the ZWP's implementation.

This report, which has been commissioned by ZWS, sheds light on the financial costs implied by the measures proposed in the Zero Waste (Scotland) Regulations, and outlined in the consultation on the Regulations.[6] It also contains an analysis of the environmental costs and benefits of the same Regulations. Broadly speaking, these environmental impacts include:

- Changes in the level of emissions of greenhouse gases (GHGs)
- Changes in the level of emissions of other air pollutants (oxides of nitrogen (NOx), oxides of sulphur (SOx), particulate matter (PM), dioxins and some heavy metals), which have consequences for human health; and
- Changes that arise from the application of compost / digestate to land.

The analysis includes the changes in emissions associated with avoiding the use of primary materials, or avoiding the generation of energy through the use of fossil fuels, which the processes being encouraged by the ZWP are expected to deliver (further detail is given at Section 0 below).

1.1. Structure of the Report

The rest of this report has the following structure:

- Section 2 sets out the Objectives for the study;
- Section 3 includes some brief Notes on Methodology;
- Section 4 describes the Approach to Modelling, including key assumptions underpinning the work;
- Section 5 presents the main Results alongside discussion of them;
- Section 6 describes Other Key Issues and Sensitivity Analysis which have a bearing on the results;
- Section 7 sets out the key Conclusions from the work.

2. Objectives

The Objective as set out in the ITT is as follows:

> *to undertake an economic cost benefit analysis to determine the (net) estimated costs of implementing the Scottish Government's Zero Waste Plan and the regulations detailed in 3.2 against a 'business as usual' scenario. This work should consider and identify all costs and benefits (direct, indirect and wider social) and, where possible, estimate these for both the public and private sectors.*

Our response to the ITT noted that there are a number of issues associated with such a study and that we would seek to illustrate the costs in terms of the effects of the change from the Business as Usual (BaU) Scenario to the Zero Waste Plan (ZWP) one. It was subsequently agreed that we would model:

1. For household waste, the full financial costs of the two different options. The Scottish Government is interested in the effects of the ZWP on public finances, and this effect is felt principally in respect of household waste. For this stream, estimates are provided for the total costs of the measures, and the changes in these costs;
2. For other waste streams, the difference between the costs associated with the two Scenarios. For these streams, the additional effort required in developing the total costs in the BaU Scenario were deemed to

[6] *Scottish Government (2011) Regulations to Deliver Zero Waste: A Consultation on the proposed Zero Waste (Scotland) Regulations 2011, available at:* *http://www.scotland.gov.uk/Publications/2011/02/09135833/0*

be excessive relative to the benefits of providing this information. It was agreed that the most important figures were related to the changes between the BaU and ZWP Scenarios; and

3. For all streams together (i.e. in the aggregate), the environmental costs. The approach to estimating these has been based upon figures underpinning the Carbon Metric[7] (which is used to measure recycling rates under the ZWP) and on previous peer-reviewed work undertaken on behalf of WRAP.[8] The details of the analysis are not provided in this report and the reader is referred to the source documents.[9]

We have interpreted the split between public and private sector as follows:

1. The public sector costs are those related to household waste only. We recognise that local authorities or their contractors might be involved in the collection and treatment of commercial waste. However, to the extent that they do this, they should cover their costs through charges levied upon the businesses which they serve;
2. The private sector costs are related to those associated with the commercial and industrial waste streams, and the construction and demolition waste stream. To the extent that the management of C&D waste related to public sector projects, then there may be some part of these costs which are passed through to local authorities or central government. However, the costs are incurred, in the first instance, by businesses in these sectors.

The household, commercial and industrial, and construction and demolition waste streams were modelled separately to allow for their distinct characteristics and dynamics to be taken into account. Results are presented for each stream accordingly (as well as in aggregate).

The 'wider social' impacts are not given further consideration, reflecting the level of resourcing in the study, and the level at which it is carried out (and this was made clear in our response to the ITT). A number of studies clearly suggest that there would be some additional potential for job creation through the ZWP. In terms of the benefits for Scotland, however, the magnitude of this potential depends upon the ultimate destination of, for example, the additional materials being collected for recycling. If materials are exported for recycling, then the job creation potential for Scotland itself is reduced, albeit that there may be additional jobs in collection, sorting, treatment of materials, and in the construction phase for these facilities. It should also be noted that our assessment of environmental costs also covers the main impacts, to the extent that these are known, of the changes in waste management upon human health. Hence, the environmental costs cover some issues which are often considered under the heading of 'social' impacts.

It was requested that the modelling should develop projections to the financial year 2025/26. These projections incorporate estimates as to the way in which the different waste streams (household, commercial, industrial, and construction and demolition) are handled, down to the material specific level. This approach has been taken in developing both scenarios. The scenarios are summarised as follows:

- **Business as Usual (BAU), in which the policy environment includes only those policies which have already been announced (such as the escalating landfill tax);**
    - Landfill tax has been modelled to reach £80 per tonne in 2014/15, remaining constant, in real terms, thereafter;

It was requested that the scenario should be developed so as to meet EU requirements for a reduction in landfilling of biodegradable municipal waste (BMW), and EU requirements for recycling, which are as follows:[10]

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[7] *Zero Waste Scotland (2011) The Scottish Carbon Metric, available at: http://www.wrap.org.uk/downloads/Technical_Report_FINAL.6fc98afe.10581.pdf*

[8] *Eunomia (2010) Feasibility of Landfill Bans Research, Final Report for WRAP, March 2010.*

[9] *See footnotes 2 and 3 above.*

[10] *These requirements arise from Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste (Official Journal L 182 , 16/07/1999 pp 0001 – 0019) and Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Official Journal L312/3, 22/11/2008, pp.3-30). The WFD requests (Article 22) that Member States take measures to 'encourage' separate collection of biowaste, and its treatment. The Landfill Tax and the systems of FITs might reasonably be viewed as measures which do, indeed, encourage this, but since we could not be expected to model a 'level of encouragement', we have not done so.*

- A maximum of 1.8 million tonnes of BMW sent to landfill in Scotland by 2013;
- A maximum of 1.26 million tonnes of BMW sent to landfill in Scotland by 2020;[11]
- In line with the revised Waste Framework Directive;
  - The preparation for re-use and recycling of 50% by weight of waste materials (paper, metal, plastic and glass) from household and similar wastes by 2020;
  - 70% recycling / reuse, preparation for re-use and other recovery of C&D waste by 2020;

- **Zero Waste Plan, in which the following policies are also introduced:[12]**
  - Zero Waste Plan target of 70% recycling, on the basis of the carbon metric, is met for all waste streams (individually) by 2025;[13]
  - A maximum of 5% of waste is sent to landfill by 2025;
  - The following regulations are introduced (note that the form of these is not yet finalised so some description of our assumptions regarding their form is given below):
    - A requirement to source segregate and separately collect key dry recyclable materials (paper, card, glass, metals, plastics and textiles) and food waste due to the environmental benefits of managing biowastes separately;
    - A ban on mixing separately collected recyclable materials is implemented;
    - A ban on sending key recyclable materials to landfill is put in place;
    - A restriction on inputs to energy from waste (EfW) facilities is implemented;
    - A ban on waste disposal to landfill is implemented.

[11] *Note that these figures take into account the revised definition of municipal waste which the UK has been requested to adopt by the European Commission.*

[12] *See Scottish Government (2011) Regulations to Deliver Zero Waste: A Consultation on the proposed Zero Waste (Scotland) Regulations 2011, available at: http://www.scotland.gov.uk/Publications/2011/02/09135833/0*

[13] *Zero Waste Scotland (2011) The Scottish Carbon Metric, available at: http://www.wrap.org.uk/downloads/Technical_Report_FINAL.6fc98afe.10581.pdf*

3. Notes on Methodology

3.1. Approach to the Analysis of Costs and Benefits

ZWS and the Scottish Government have indicated that in respect of costs, they are most interested in the full financial costs to the relevant actors in the economy, incorporating the impact of taxes and subsidies. The merit of this approach is that it reflects the costs which actors are likely to face in the market place under a given range of policies (and these are the prices to which they will be responsive).

This is not the approach which is conventionally followed in cost benefit analysis. In such analyses, it is usually the case that the financial costs considered exclude all taxes and subsidies (since these represent transfers which are unrelated to the financial resources used to deliver a given service). One reason for adopting this approach is that some taxes have, as one of their objectives, the internalisation of environmental costs (i.e. the inclusion within the financial calculus of environmental damages). If a cost-benefit analysis includes these taxes in the financial costs, whilst also seeking to estimate environmental costs, there will be some double counting of these environmental costs when these are added together. [14]

So as to avoid presentational issues associated with the issue of double counting, we have presented the environmental impacts separately from the financial costs.

3.1.1. Financial Costs

Reflecting the above discussion, all financial costs are modelled including taxes. This raises some issues regarding exactly what should be used to represent the financial costs of the facilities and processes being considered. By and large, we have sought to estimate the costs of facilities under reasonable assumptions regarding the cost of capital, the cost of maintaining the facility, the revenues accruing from generation of energy, the costs associated with residue disposal, and other operating costs of facilities. These will not necessarily be the same as 'gate fees' offered in the market at any given time. For various reasons, related to the balance of supply and demand, gate fees may be either above or below the actual costs of operating a facility at a given rate of profit. In markets which are not showing major imbalances between supply and demand, however, our costs will be similar to prevailing gate fees.

3.1.2. *Environmental Costs*

It was agreed with the Steering Group that we would report monetised environmental costs / benefits (i.e. the externalities) associated with the change to the ZWP where it was possible to do so. For the most part (there are some exceptions with regard to, for example, irrigation water saved through use of compost / digestate), the approach has been to assess the quantity of a given pollutant being emitted and multiplying by a relevant figure for the 'unit damages' caused by the emission.

The assessment of environmental costs in this analysis includes the following key elements for a given facility or process:

1. The GHG emissions associated with the use of electricity, heat and fuel used to operate the process (e.g. electricity and heat used to run an anaerobic digester, or an incinerator);
2. The GHG emissions associated with the functioning of the process itself (e.g. emissions of methane from landfill, or of CO_2 from combustion of materials containing fossil carbon, such as plastics);[15]
3. Emissions of air pollutants for which credible sets of damage costs are available (oxides of nitrogen (NOx), oxides of sulphur (SOx), particulate matter (PM), dioxins and some heavy metals). The main impact of these pollutants is their effect on human health;

[14] *In conventional Cost Benefit Analysis, the approach taken to estimating financial costs effectively excludes the impact of measures such as landfill tax, designed to reflect (i.e. internalise) the environmental costs of landfill, and the Renewables Obligation / Feed in Tariffs, designed to support the development of technologies generating renewable energy. This is because the intention is to focus on the financial costs in terms of the financial resources used (as opposed to including taxes and transfers) and to capture the environmental costs and benefits as they actually occur. To count the landfill tax on the financial side, and to add to it the environmental costs of landfilling would effectively amount to some double counting of the environmental costs of landfilling (however imperfectly landfill tax might internalise environmental costs).*

[15] *Note that we have followed the decision in the analysis underpinning the carbon metric to discount (i.e. not to include) emissions of carbon dioxide associated with combustion or degradation of non-fossil carbon.*

4. Emissions which are avoided either from the recycling (and the use) of secondary materials (replacing primary ones), or the generation of energy (replacing other sources of energy generation);
5. Effects of using compost and / or digestate on land, including avoided impacts associated with displaced nutrients, reduced requirement for water use, and reduced requirement for pesticide use.

Some impacts are not so easy to capture in monetary form. These include, for example:

1. Negative Impacts
    a. Effects of accidents (all facilities);
    b. Effects of temporary / extended breaches in emissions limit values;
    c. Disamenity effects (for example, odour, or nuisance, or visual impacts);
    d. Emissions to water courses;
    e. Externalities related to construction and input materials for facilities;
    f. (Long-term) effects of landfills on groundwater (including the landfilling of treatment residues);
    g. (Long-term) effects on land quality;
    h. Health effects associated with bioaerosol emissions; and
    i. Heath effects associated with other emissions to atmosphere other than those for which monetary damage costs have been obtained.
2. Positive Impacts
    a. Reduced potential for floods associated with use of compost / digestate;
    b. Reduced potential for wind-blown soil erosion associated with use of compost / digestate (and associated health benefits);
    c. Consumer surplus associated with, for example, recycling;[16] and
    d. Time-limited sequestration of carbon in soils / landfills.

In the main, we have relied upon work carried out previously for WRAP, and for the sake of conserving space, we do not re-attach the large quantity of documentation underpinning the analysis, but refer the reader to the primary source.[17] A key exception to this approach was in respect of the emissions of GHGs. It was agreed that, as far as possible, we would base the GHG emissions on the Carbon Factors which underpin the carbon weightings which are the basis for the calculation of recycling rates in the carbon metric.[18] However, there are some waste management practices which do not yet have carbon factors officially backed by the Scottish Government linked to them in the carbon metric (this, we understand, is work in progress). Hence, for these 'missing' processes, we have used estimates of these from previous peer-reviewed work to generate the full picture regarding GHGs on which to base the calculation of the effects of the changes in tax.[19]

Regarding the valuation of impacts, for emissions of GHGs, we have used values from HM Treasury and DECC Guidance.[20] For non-GHG air pollutants, we used two sources:

- The first was the UK Government's Interdepartmental Group on Costs & Benefits (IGCB) Guidance on Air Quality Damage Costs. [21] This covers damage costs for particulate matter (PM_{10}), oxides of nitrogen (NO_x), sulphur dioxide (SO_2) and ammonia (NH_3);
- The second were UK-specific damage costs for taken from the Clean Air for Europe (CAFÉ) programme, and the Benefits Table (BeTa) database. [22] Damage costs for carbon monoxide are taken from a Danish study.[23]

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[16] Consumers appear to be 'willing to pay' for recycling services and as such, conventional economic analysis suggests that they may derive some value over and above what they pay for the provision of the service.

[17] Please note that for the full details of this analysis, the reader is referred to Eunomia (2010) Feasibility of Landfill Bans Research, Final Report for WRAP, March 2010

[18] See Zero Waste Scotland (2011) The Scottish Carbon Metric, available at: http://www.wrap.org.uk/downloads/Technical_Report_FINAL.6fc98afe.10581.pdf

[19] Full details can be found in Eunomia (2010) Feasibility of Landfill Bans Research, Final Report for WRAP, March 2010

[20] HM Treasury and DECC (2010) Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal and Evaluation, June 2010, http://www.decc.gov.uk/assets/decc/statistics/analysis_group/122-valuationenergyuseggemissions.pdf

[21] Defra (2008) Damage Cost Guidance, November 2008. Available at http://www.defra.gov.uk/environment/quality/air/airquality/panels/igcb/documents/damage-cost-calculator-guidancepaper.pdf (accessed September 2009)

There remain considerable gaps in our knowledge of the environmental impacts of waste management options, and even where the knowledge is 'emergent', straightforward approaches to valuing benefits or costs rarely exist.

To summarise:

1. For recycling of the main materials, and for composting and anaerobic digestion, we make use of the values for GHG emissions which have underpinned the carbon metric;
2. Since the figures underpinning the carbon metric are not available for all treatments, we fill gaps with figures based upon work undertaken previously in peer-reviewed work for WRAP;
3. These unit (per tonne) GHG emission figures, expressed in tonnes CO_2 equivalent, are then multiplied by the relevant damage costs (these vary by year) based upon Government guidance;[24]
4. To these GHG-related damages, we added the non-GHG externalities from previous work on landfill bans;[25]
5. This approach gives a 'damage cost' per tonne of waste being treated in one or other way; and
6. We then multiply by the changes in waste quantities going to one or other of these treatments to give the full magnitude of the benefits from switching from BaU to ZWP in any given year.

This approach enables us, through extracting the changes in mass flows which occur between the BaU and the ZWP Scenarios, to understand the impacts of the policies being implemented under the ZWP.

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[22] *M. Holland and P. Watkiss (2002)* Benefits Table Database: Estimates of the Marginal External Costs of Air Pollution in Europe*, Database Prepared for European Commission DG Environment; AEAT Environment (2005)* Damages per tonne Emission of $PM_{2.5}$, NH_3, SO_2, NO_x and VOCs from Each EU25 Member State (excluding Cyprus) and Surrounding Seas, *Report to DG Environment of the European Commission, March 2005*

[23] *COWI (2002)* Valuation of External Costs of Air Pollution *– Phase 1 Report (TRIP). The Danish Environmental Research Programme. Further referenced in Munksgaard et al. (2007) An environmental performance index for products reflecting damage costs,* Ecological Economics *(64), 119-130.*

[24] *HM Treasury and DECC (2010) Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal and Evaluation, June 2010, http://www.decc.gov.uk/assets/decc/statistics/analysis_group/122-valuationenergyuseggemissions.pdf*

[25] *Eunomia (2010) Feasibility of Landfill Bans Research, Final Report for WRAP, March 2010*

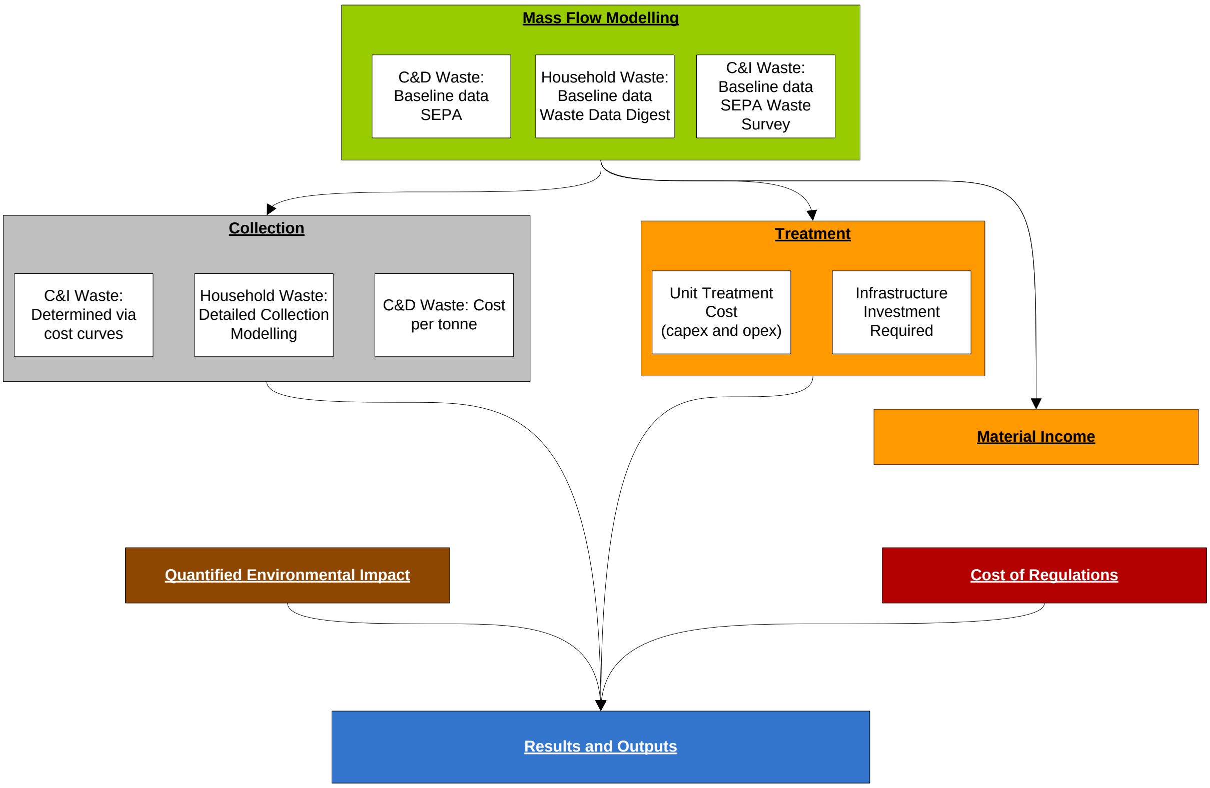
4. Approach to Modelling

This Section sets out the approach to the modelling, as well as a description of the approach to modelling BaU and ZWP Scenarios. The description includes some of the underlying assumptions driving the modelling.

4.1. Model Development

A spreadsheet model has been made available to ZWS and the Scottish Government from upon which the analysis is based. Figure 1 presents a diagram of the constituent elements of the model. The methodology and key assumptions made for each of the elements are described in more detail in the following sections and the accompanying Appendices.

Figure 1: Model Flow Diagram



4.2. Mass Flow Modelling – Current Situation

The mass flow modelling undertaken for this work is split between household waste, commercial waste, industrial waste and construction and demolition waste. Municipal waste is deemed to be composed of household and a proportion of commercial waste (i.e. the 'other similar waste'), in line with the revised definition of municipal waste which the UK has been asked to adopt by the European Commission. Some manipulation of data was required to ensure the data being used is consistent with the figures now being used by Scotland as targets for the quantity of biodegradable municipal waste landfilled in future years. This approach was agreed with Scottish Government (see Section 4.4.3 below).

4.2.1. Household Waste Data

The household waste arisings for the year 2008 and the recycling rates have been taken from the SEPA Waste Data Digest 10. Waste composition has been taken from the most recent compositional analysis of household waste in Scotland in 2009.[26] Further details are given in Appendix 1. Combining the two gives information regarding the quantity of each of the different materials in the household waste stream, as well as the proportion of each of these materials which is being recycled.

The fates (i.e. how waste is managed) in the current situation were also taken from the SEPA Waste Data Digest.

[26] *WasteWork and AEA, on behalf of Zero Waste Scotland (2009) The Composition of Municipal Solid Waste in Scotland, available at: http://www.wrap.org.uk/downloads/Scotland_MSW_report_final.54690ac2.8938.pdf*

4.2.2. C&I Waste Data
The commercial and industrial sectors were modelled separately, due to our expectation that the waste streams have distinct and different waste compositions, because of their differing growth rates, and because of the different approaches to treatment. The data regarding waste quantities are the 2008 figures taken from SEPA Waste Data Digest 10.

No detailed composition data exist for either commercial or industrial waste. For the composition of commercial waste, we carried out some manipulation of the analysis of landfilled commercial waste from the Welsh Assembly Government to arrive at a composition of the totality of commercial waste. This involved us gathering data on the amount of commercial waste, by material, which was being recycled at the time and adding these materials to the quantities in residual waste to give a full picture of the composition of the total waste stream (rather than simply the composition of the residual waste).[27]

For industrial waste composition, the same source was used, but rather than adding the recycled waste back to the residual commercial waste, we assumed the residual waste composition was as presented in the Wales study.

It should be noted that C&I tonnages are reported in calendar year so were converted to financial year using the following methodology:

$$FY_{n/n+1} = 0.75 \times CY_n + (CY_{n+1} \times 0.25)$$

where FY = Financial Year and CY = Calendar Year.

4.2.3. C&D Waste Data
C&D waste data is taken from SEPA Waste Data Digest 10. Composition data has been taken from a study by the Environment Agency in Wales because no such data exists for Scotland.[28]

4.3. Growth Rates
Projecting forward growth rates is fraught with difficulty. There are two principles we have followed in making the projections:

1. There are no projections which suggest significant increases in quantities over time; and
2. Even where waste reduction is entirely possible, the historic data from which to base such a projection is weak. Hence, no unduly large negative growth rates have been applied, not least because they might give an unrealistic view of what may happen in future.

In any case, it should be born in mind that the principle concern of this study is the change from BaU to ZWP, and that the growth rates in each Scenario are assumed to be the same.

The following forward projections were agreed with Scottish Government and applied under both the BAU and ZWP scenarios in the Central modelling case.

1. Household waste:
   a 0% growth rate in total household waste was applied. This reflects the trend in recent years, which has shown arisings of household waste to be essentially flat;
2. Commercial waste:
   there is considerable uncertainty about the quantity of commercial waste generated (and its management). Two data sources are available: The SEPA Waste Data Digest, and the data from the SEPA 2009 business survey. The discrepancies between datasets are significant and are revealed clearly when one seeks to square this data with information from site returns. We have used the data from the Data Digests. The most recent data show a significant drop (14%) in commercial waste arisings for 2009 relative to 2008. To the extent that is an accurate reflection of the reality, this is likely to be attributable, in large part, to the decline in economic activity in Scotland in this period. Previous analysis we have undertaken suggests that the underlying trend growth in commercial waste arisings – to the extent that

[27] *WRc plc (2011) Statistical Analysis of Scotland Business Waste Survey Data for 2009, Final Report for SEPA, March 2011*

[28] *Building the future 2005-06: A survey on the arising and management of construction and demolition waste in Wales 2005-06*

this can be known with any certainty (the data upon which to base the analysis is limited) - is small, but positive.[29] More recent datasets have cast doubt on this, but these data have been gathered in the midst of a sharp recession, and the methodologies for grossing up data may not be robust.[30] Therefore, we have assumed that post 2009, waste arisings increase to a level between the 2008 and 2009 figures by the year 2014. Thereafter, we have assumed a 0% growth in commercial waste arisings;

3. Industrial waste:
   As with commercial waste, the data here is of poor quality so that eliciting reliable trends is not possible. The Waste Data Digests record a significant (20%) drop in industrial waste arisings between 2007 and 2008, and a further (13%) reduction between 2008 and 2009. As with commercial waste, this is likely to be attributable, in large part, to the decline in economic activity in Scotland in these years. It was agreed that we would model a modest decline of 0.7% per annum. In addition, to account for an expected increase in economic activity over the coming years, it was agreed that we should project an increase in waste generation post-recession, but only to levels (by 2014) where they would have been if an annual 0.7% per annum reduction had been applied to the 2008 figure;
4. Construction and demolition waste:
   The data used for 2008 comes from SEPA Waste Data Digest 10. The Data Digests record a significant decline in C&D wastes of 20% between 2006 and 2007 (i.e. pre-recession). A further 9% decline was recorded between 2008 and 2009. We believe that the potential for waste prevention in the C&D sector is significant, and instead of modelling a significant bounce back in waste generation, we have modelled a reduction in arisings of 0.7% from 2009 onwards. It might be argued that this decline in arisings should be higher, but for the sake of prudence in the context of this modelling, it was agreed that the projected decline in waste quantities should be a modest one.

It should be noted that the choice of these growth rates was intentionally pragmatic. This is an area of some uncertainty, but as regards the modelling of the differences between the BaU and the ZWP Scenarios, to the extent that growth rates are the same in both Scenarios, then the choice of growth rate becomes no more than a scaling factor determining the magnitude of the differential costs and benefits between the Scenarios, and a determinant of the absolute level of cost implied for management of household waste. Hence, whilst results will be sensitive to growth rates in terms of their size, the growth rates will not, by and large, alter the key messages (in terms of whether costs increase or decrease, or whether environmental benefits rise or fall).

4.4. Modelling the BaU and ZWP Scenarios

In modelling the effects of BaU and ZWP Scenarios, as discussed above, base data for the most recent year for which data is available were used and arisings were projected forward at the growth rates discussed in Section 4.3. The key issues in the modelling of projections relate to how the wastes generated would be managed in the years after that for which data was most recently available / estimated.

It is important to note that the BaU Scenario implies something beyond 'what happens today'. It actually demands the development of a projection for the management of waste which runs out to 2025/26, the final year for the analysis. This has to take into account the effect of a range of policies that have already been announced, most notably, the increases in landfill tax. The approach and key assumptions made to develop the Scenarios are described in the following Sections. It will be appreciated that there are limitations in the quality of the data even for current years. The development of projections into the future is, therefore, an exercise which requires considerable judgement and assumptions, and evidently, the projections are therefore indicative and should not be taken to be perfect representations of the future.

4.4.1. Business as Usual (BAU)

In developing the business as usual baseline projections the key policy driving behaviour is the landfill tax. The tax is set to increase year-on-year by £8 per tonne until 2014/15, at which point, it will have reached a level of £80 per tonne. Thereafter, we have assumed the tax remains constant in real terms. Some mechanism is required for estimating the effect of this policy. The way in which the tax affects the management of waste also forms the basis for the estimation of the costs of the scenarios. In developing the BaU Scenarios, we took the approach that we would model the effects of the tax first, and then review the need to make additional changes

[29] This work was carried out for a private sector client in the context of understanding the potential availability of different waste feedstocks over time. It drew upon all the relevant datasets available at the time. The work was conducted late in 2009 but is not publicly available.

[30] Defra and Government Statistical Service (2010) Survey of Commercial and Industrial Waste Arisings 2010 – Interim Results, Statistical Release 201/10, 10 November 2010, http://www.defra.gov.uk/news/files/2010/11/1011stats.pdf

in BMW landfilled and / or recycling so as to meet the relevant EU-related targets. As will become clear, in the majority of cases, this proved not to be necessary.

Household Waste

Household waste is split in the modelling into kerbside collected waste, and waste collected at bring sites / HWRCs. We would have liked the data on bring and HWRC to be split since the approaches are somewhat different, and the costs and approaches to dealing with materials from these routes are not the same. However, this data was not available for this project. The simple split available to us also makes no account for aspects of the service which tend to have relatively high unit costs of collection, such as litter, or street sweepings, or bulky waste. This will tend to lead to an underestimate of the overall costs of household waste collection. This merely reflects the fact that the data was not available in the most desired form.

Kerbside Collection

For household waste collected at kerbside, a series of models were developed for the kerbside collection of waste in our proprietary software for modelling options for collection and treatment, Hermes.[31] The basics of the modelling approach are described in Appendix 2. The aim was to consider how, as systems change to increase the recycling of various materials, the costs of collection change. In particular, the intention was to understand how, under BaU, the local authorities would respond to the landfill tax. Effectively, we sought to inform the view as to what a 'rational' local authority might do in response to the tax – at what point would the marginal costs of recycling increase to a level which exceeded the avoided costs of refuse collection and disposal?[32]

The systems chosen for modelling were designed to reflect a plausible evolution in the development of kerbside collection services, based upon what appeared to be 'typical' schemes in operation in Scotland. This followed a review of the systems which appeared to be in operation at the time of writing. Models were developed for Urban, Rural and Mixed authorities and were based on systems described in Table 1. The performance of the systems was assumed to vary based upon the nature of housing stock (and based upon experience with other local authorities). The performance in the final column of the Table reflects the application of different participation, set-out and capture rates for the specific authority types (and within these, the housing types) based on experience with a range of authorities.[33] The models also were based around the composition of Scottish household waste according to the most recent study. [34] It should be noted that this study reports a high proportion of wastes which cannot easily be targeted for recycling (e.g. fines, miscellaneous combustibles and non-combustibles) so that achieving high rates of recycling becomes more challenging where it is assumed that this composition accurately reflects waste collected from households at the kerbside.

Interestingly, under the systems investigated, the optimal level of recycling for local authorities for whom the marginal benefit of avoided disposal relates to the cost of landfilling is the highest one achieved under the models as described in Table 1. In other words, where services are operated efficiently, then once the tax reaches £80 per tonne, the optimal level of recycling is effectively the highest one that can be achieved (within reason) using the services modelled. Additional recycling over and above these levels requires additional services, which we have assumed will not be introduced under BaU (but which effectively have to be introduced under the ZWP Scenario, for example, to increase the rate of recycling of textiles, for which the weighting under the carbon metric is extremely high).

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[31] Hermes has been used in a range of projects for WRAP, Defra, WAG, the Irish Government, and across local authorities responsible for collecting around 30% of all household waste in the UK.

[32] Evidently, authorities for whom the costs of residual waste management may be lower than the costs of landfilling because they already have a treatment provider, or whose contracts limit the extent of savings which are generated, at the margin (for example, because of the existence of so-called 'put-or-pay' clauses), through avoided disposal are likely to confront a somewhat different set of conditions to those described here.

[33] Eunomia has carried out detailed cost modelling, including reviews of existing performance, for local authorities accounting for around 30% of all UK households. The figures have been based upon our expert judgement.

[34] WasteWork and AEA, on behalf of Zero Waste Scotland (2009) The Composition of Municipal Solid Waste in Scotland, available at: http://www.wrap.org.uk/downloads/Scotland_MSW_report_final.54690ac2.8938.pdf

Table 1: Collection Systems Modelled

Nature of Authority	Type of System (current)	Performance (% kerbside recycling)	Type of System (future)	Performance (% kerbside recycling)
Urban	Fortnightly dry kerbside sort / fortnightly comingled Free fortnightly garden in 33% of hhlds Weekly refuse in wheeled bin	25%	Weekly dry kerbside sort / fortnightly comingled Food waste collected weekly on same pass where dry is kerbside sort, or on separate vehicles where dry is comingled Free fortnightly garden in 33% of hhlds Fortnightly refuse in wheeled bin	46%
Rural	Fortnightly dry kerbside sort / fortnightly comingled Weekly refuse in wheeled bin	14%	Weekly dry kerbside sort / fortnightly dry where comingled Food waste collected weekly on same pass where dry is kerbside sort, or on separate vehicles where dry is comingled Charged garden waste collection Fortnightly refuse in wheeled bin	56%
Mixed	Weekly dry kerbside sort / fortnightly comingled Free fortnightly garden in 70% of hhlds Fortnightly refuse in wheeled bin	32%	Weekly dry kerbside sort / fortnightly dry where comingled Food waste collected weekly on same pass where dry is kerbside sort, or on separate vehicles where dry is comingled Free fortnightly garden in 70% of hhlds Fortnightly refuse in wheeled bin	60%

In the BaU Scenario, however, it is assumed that even though a rational response to the tax would be to go for high capture systems, not all local authorities achieve this level of recycling. The reason for this is that they are deemed to be constrained in the recycling rates they can achieve either by their existing, or their firmly developed plans, for the development of residual waste treatment facilities. This assumption was made at the request of the Scottish Government. This constraint has been applied in the following manner:

1. We have reviewed, using information from SEPA, the existing waste treatment facilities and the sources of their waste;
2. We have taken information from Scottish Futures and have identified those projects that are already in procurement. We have assumed that the capacities reported by them are a faithful reflection of what would be procured in the absence of the ZWP (i.e. under BaU);
3. We have assumed that (partly reflecting views that HWRC recycling will increase anyway – see below) under BaU the material likely to be delivered for treatment is residual waste from kerbside collections;
4. We have estimated the proportion of the kerbside collected waste that would be accounted for by the treatment facilities concerned (call this X%);

5. We have constrained recycling rates at local authorities such that they can reach a maximum of (100-X%) in future; and
6. These rates are assumed to be achieved in 2014/15 reflecting the view that the levels which landfill tax is expected to reach have been announced well in advance of this date.

These are somewhat simplistic assumptions, but they reflect the view of the Scottish Government that in the absence of the ZWP Regulations, there is an increased likelihood that local authorities will opt for approaches which are less focused on recycling and waste prevention, and more focused on simply 'not landfilling'.

For each authority, the recycling rate assumed to be achieved under the £80 per tonne landfill tax (either as per Table 1 for those authorities unconstrained by residual waste treatment contracts / intentions, or the 'constrained' figure calculated as described in points 1-6 above) was then multiplied by the kerbside collected waste to give a recycled quantity, and hence, a recycling rate for all Scotland. The costs for kerbside waste collection for each authority were estimated from the detailed kerbside modelling described above and in Appendix 2. The figure chosen for each authority was that which most closely resembled a) the system currently used by the authority concerned, and b) the rate which the authority is assumed to achieve (depending upon the constraint applied) in 2014/15 (again, this is a simplifying assumption since in the ideal case, modelling would be undertaken for each specific local authority). This gave the costs for each authority, and hence, the costs for all Scotland in the year 2014/15. The recycling rates were assumed to remain constant after the tax stops increasing in real terms in 2014. Associated costs were assumed to remain constant in real terms, rising only with changes in the number of households.[35]

HWRC and Bring Waste

The HWRCs and Bring materials are dealt with in a different way to the kerbside collected waste. It is expected that this material comes mainly from HWRCs. Under the BaU, approach, the existing capture rates for different materials have been estimated (from Waste Data Digest data and from the composition analysis carried out for Zero Waste Scotland). A problem here is that, as mentioned above, we did not have access to recycling data that was split across Bring and HWRC routes - this has been a common way of reporting data under waste Dataflow, but we would encourage reporting of this data in more distinct categories in future since the operational issues for the streams are rather different (and they tend to have different materials as their focus).

Under the BaU Scenario, we have assumed modest improvements in capture of the key materials generally targeted at HWRCs, especially where these looked low compared with what we have come to expect on the basis of considerable experience with other UK local authorities. This increases recycling rates of Bring / HWRC waste up to 2014/15, but not thereafter. This is how local authorities are assumed to respond to the tax, recognising that better recycling at HWRCs is often a cost-saving activity for local authorities, though recognising also that there may be constraints locally, either in terms of site provision, or available space, which may make improving performance less straightforward than we have assumed.

For the cost of managing this material, we have used figures for Bring and HWRC waste management from previous work for the GLA.[36] A weighted figure has been applied on the basis that we estimate (and this can only be an estimate as there is no clear information to support this) that 80% of the bring / HWRC material is from HWRCs, with the remainder being collected through bring schemes. This figure is applied to all Bring and HWRC tonnage. However, to the extent that recycling increases, we have assumed that this is most likely to be (in net terms) from HWRCs and have priced the recycling of additional material at a 'marginal cost' of additional recycling at HWRCs reflecting improved performance and operation of HWRCs. This figure has been based upon previous work for WAG, where we based the incremental cost of additional (over and above BaU) recycling on a model of a programme of investment to upgrade and expand the network of HWRCs.[37] This figure – an average figure -

[35] *2006 - 2009 data were taken from National Statistics (2010) Estimates of Households and Dwellings in Scotland, 2009, Report for General Register Office for Scotland, 16 September 2010. Projections were taken from National Statistics (2009) Projected Population of Scotland (2008-based), Report for General Register Office for Scotland, 21 October 2009, http://www.gro-scotland.gov.uk/statistics/theme/population/projections/scotland/2008-based/index.html. These projections were provided for all Scotland. We have assumed household sizes remain constant over this period, and have simply increased the household numbers in each local authority at the rate of increase of population. The increase equates to a compound growth rate in household numbers of around 0.34% per annum in the period 2008-2023. It may be noted that in conjunction with the household waste growth rate assumptions, this implies a diminishing quantity of waste per household.*

[36] *Eunomia (2010) Economic Modelling for the Mayor's Municipal Waste Management Strategy, Final Report for the GLA, April 2010*

[37] *Eunomia (2007) Scoping New Municipal Waste Targets for Wales, Report for Welsh Local Government Association.*

was updated to 2010 Sterling Values and is assumed to be constant in real terms for all additional recycling at HWRCs over and above that achieved in the current situation. The figures used are summarised in Table 2.

Table 2: Unit Costs for Bring / HWRC Management

Activity	Unit Cost
Cost per tonne - HWRC (current)[1]	£43
Cost per tonne – Bring (current)[2]	£33
Weighted Average (assumed 80% HWRC, 20% bring)	£41
Cost per tonne for additional recycling at bring / HWRC[3] (assumed most likely to be HWRCs as recycling tonnage from HWRCs is likely to increase whilst that for Bring may even fall as kerbside services improve)	£85

Sources:

[1] *Eunomia (2007) Scoping New Municipal Waste Targets for Wales, Report for Welsh Local Government Association.*

[2] *GLA*

[3] *Eunomia (2007) Scoping New Municipal Waste Targets for Wales, Report for Welsh Local Government Association*

Management of Residual Waste

Regarding residual waste management, we are aware of facilities in place, those in construction and those with planning consent. However, with the LAS suspended, there are few incentives for local authorities to develop non-landfill residual waste treatment capacity other than that provided by the rising landfill tax. The tax is due to reach its highest known level in 2014/15, and actors have been aware of this for some time. We have assumed, therefore, that no additional residual waste treatment other than that already being taken through active procurements. This assumes, effectively, that there is no meaningful merchant market of which local authorities avail themselves. There are reasons why this might indeed be expected (not least, the restrictions which apply EU-wide to local authority procurement) but the market might be less encumbered by the rigidities we have assumed. We have also assumed no major increase in export of residual household waste for recovery.[38] The implications of this assumption are discussed in Section 6.2.

Commercial Waste

For the commercial waste sector, the emphasis of the modelling has been on the changes in the costs of collecting and recycling the materials targeted by the ZWP. Under the BaU, we have used a model developed in house of the costs of recycling marginal tonnes of waste from the commercial sector, using data on Scotland businesses, to estimate how much commercial waste will be recycled at a given disposal cost. This allows us to estimate the recycling rate at £80 per tonne tax in 2014/15.

These models have been used for systems that collect:

1. paper and card, metals and plastics;
2. glass; and
3. food waste.

Clearly, other configurations for collecting commercial waste do, and will continue to, exist. The aim was to model a representative approach to collecting commercial waste, and to focus on those materials generally included in collections, and targeted for mandatory collection under the ZWP. The only material not being modelled which is targeted under the ZWP is textiles. This material is important in the context of the Carbon Metric, but under our estimation, textiles account for only 0.9% of commercial waste. As such, its role is not so significant. This is not to say that recycling of commercial textile waste is not important. Rather, it is to highlight the fact that the collection of such material is unlikely to be through the same types of service as paper and card, etc.

The first step in the process was to understand the business waste landscape. At the time of undertaking this piece of the research the 2008 SEPA business survey was the most up-to-date.[39] From this the proportions of waste from each business type, both commercial and industrial, were determined (see Table 3).

[38] *Such exports are in line with EU legislation but are subject to prior notification and approval by SEPA.*

[39] *SEPA (2008) Table 3: SEPA Commercial and Industrial Waste Producer Survey 2008*

Table 3: Waste Generation by Business Type in Scotland

Business sector	**Percentage**
Fishing	0.3%
Mining and quarrying	0.7%
Food and drink	7.2%
Textiles and leather	0.6%
Wood and paper	4.9%
Chemicals	4.1%
Mineral products	1.1%
Metal and metal products	1.3%
Machinery, vehicles and equipment	1.3%
Coke, oil, electricity, gas, steam	3.7%
Water, sewerage and waste management	4.4%
Miscellaneous industrial	0.5%
Retail and wholesale	22.9%
Transport and storage	2.3%
Hotels and restaurants	8.5%
Information and communication	2.1%
Finance and insurance	1.0%
Professional, scientific and technical activities	5.0%
Administration, real estate and other service activities	11.8%
Public administration	3.0%
Education	4.1%
Human health and social work	7.0%
Arts and recreation	2.4%
Total (tonnes)	100.0%

Source: SEPA (2008) Table 3: SEPA Commercial and Industrial Waste Producer Survey 2008

The total tonnages of waste potentially requiring collection for recycling for a reduced set of business types were then calculated. The same dataset was then used to calculate the quantity of waste arising per business per week, in kgs and litres, along with data on the number of businesses in Scotland.[40] Some adjustment was also made to factor in the number of sites a particular business has, and therefore the number of collections required, giving the relevant quantity per collection, as opposed to per business (which would have included collection from multiple sites in one go). Compositions for the different business sectors were derived from a number of different studies into C&I waste.[41, 42] This then allowed the calculation of the generation of different types of waste per business sector. Reflecting the fact that not all waste is likely to be captured, maximum captures on the potential for recycling were set (see Table 4). It might be argued that these could be higher for some materials (notably, paper and card, glass, and metal). However, there is limited data upon which to base such assumptions. In the absence of better information on this matter, these remain relatively challenging targets for the captures achieved across the whole of Scotland. It should be noted that if they rise to higher rates, the implication would be that at a given level of recycling, the costs are lower. The assumption might be considered, therefore, relatively conservative for this specific analysis.

[40] *Table A2.1 of P. Wetherill (2008) UK Business: Activity, Size and Location – 2008, Report for Office of National Statistics, September 2008*

[41] *Urban Mines (2007) C&I Waste Survey 2007, Report for WAG*

[42] *ERM (2003) Carbon Balances of the UK Waste Sector, Report for Defra.*

Table 4: Maximum Captures of Waste for Recycling (all business sectors)

Waste Stream	Maximum Capture
Paper	90%
Cardboard	90%
Metal	90%
Plastic	60%
Glass	90%
Food	80%
Garden	90%
Residual and Other	0%

Source: Eunomia

At this point different waste streams were considered separately based upon the type of collection systems that would be used. Separately collected food waste, separately collected glass and comingled collection of paper, card, dense plastic and mixed cans, were modelled. For each collection type the following approach was taken.

3. Likely bin sizes were chosen based upon the volume of material requiring collection per week and a limit of 3 bins per site. This resulted in a calculation that determined how many bin lifts were required, per week, to collect all the material. This approach results in a realistic scenario where, on average, bins are not filled to high levels. The average fill rate for the different collection systems, based upon recent unpublished survey work, was estimated at around 50-60% on average.
4. To ascertain the likely costs for a business per lift an internal C&I collection cost model was used to determine the cost per lift per container for each of collections. The following assumptions were applied to estimate the cost per lift:

    a. The number of customers in each of the identified categories using a register of total VAT paying businesses;[43]
    b. The waste arisings, capture rates and compositions for different customer categories;
    c. The type of container used by each customer determined by the amount of waste produced;
    d. The frequency of collection for each service; and
    e. The typical time taken to move between customers and time taken to lift a container.
5. These costs, combined with an understanding of the tonnage collected, allowed the collection cost, in terms of cost per tonne of material, to be calculated per business type and size (measured by number of employees). A weighting factor was used to inflate the costs of collection based upon a non-marginal saving on the avoided collection of refuse. For example, removing food waste from the refuse stream and requiring 1 additional collection does not necessarily mean that 1 whole collection (or bin) of refuse will be saved. In fact, only a proportion of the saving is expected for companies generating lower quantities of waste. If the company has 1, 2, or >2 lifts per week the avoided saving on the refuse is 30%, 50% and 100% respectively.[44]

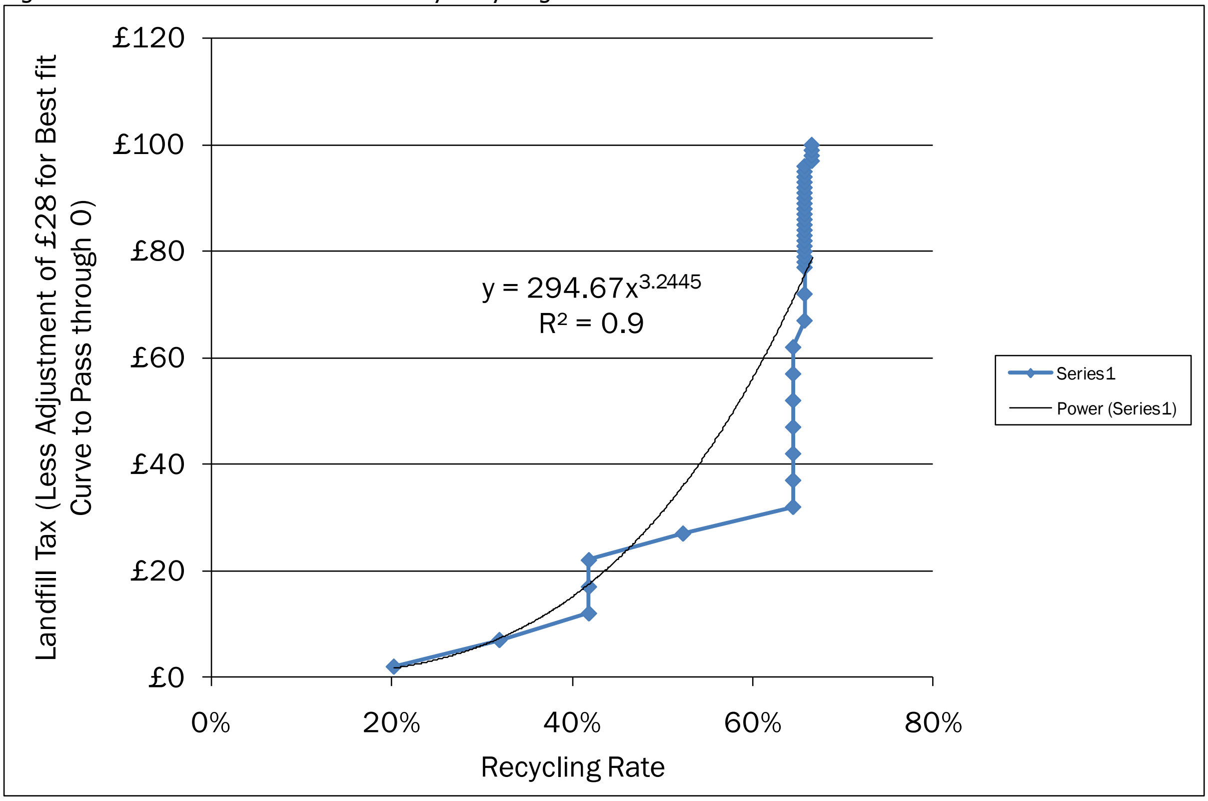
A cost curve was developed based on the assumptions and calculations discussed above. In essence this was achieved by ordering the business types and sizes from least to most expensive collections (based upon these, per tonne, collection costs). The relevant quantities of recycling that could be achieved for the different levels of costs were then plotted against the per tonne costs. This allowed the modelling to reflect the assumption that collections will happen in an economically efficient manner, collecting the 'cheapest' tonnes from easy to reach businesses initially, followed by the more 'expensive' tonnes. The trend of this relationship, or function, was then used to provide the relationship between tonnage recycled and cost of recycling. An example of this approach for

[43] ONS (2009) UK Businesses: Activity, Size and Location 2009. Note this excludes non-VAT registered SMEs, but no reliable data was available on these and their likely number (and developing such estimates was outwith the scope of this study).

[44] The situation for commercial waste is very different to that for household waste. Although the same principles apply in terms of making savings on refuse through changing activities in respect of separate collection, in practice, different commercial waste producers will be better or worse-placed to make such savings. Much depends on the services they receive, the way these are charge for, and the composition of the waste stream.

the mixed dry recycling collections is given in Figure 2 below. The aim of this task was not to generate a perfectly shaped curve (this was constrained by the fact that whilst the permutations available in terms of service provision are very large, the model simplifies this considerably so that the businesses have a limited range of choices in respect of how they 'receive' their service). Rather, it was to indicate what the shape of a cost curve might look like to gain some handle on how recycling rates might respond to changing levels of disposal cost. This is a far from perfect approach at present, but it is the first time, to our knowledge, that such cost curves have been developed for this type of purpose.

Figure 2: Cost Curve Function for C&I Dry Recycling Collections



Source: Eunomia

The costs of landfill plus tax effectively determine, in our model, the level of recycling achievement under a rationally functioning market for commercial waste collection. At that level of recycling, the models concerned give a cost per tonne for the recycling. This enables a cost for commercial waste recycling to be established from the quantities generated, and the cost per tonne figures.

This approach is based upon a number of assumptions, notably:

i. That the modelling is accurate (and even with best endeavours, it is probably only approximately correct);
ii. That the market for waste collection follows a strongly 'economistic' rationale (it might not – decisions to have some materials collected might follow a different set of principles); and
iii. That there are no market failures in the provision of, and uptake of, services (there are likely to be several, related to network effects, and information / search costs)

We have chosen to address the last of these through reducing the level of recycling which might otherwise occur in a market with no such failures. Effectively, this is achieved through reducing the level of tax which is assumed to drive the change in performance (this is equivalent to shifting the cost curve depicted in Figure 2 vertically upwards). In sensitivity analysis later in this Report (described in Section 7 below), we have explored situations where:

a) the market is perfectly rational in the BaU Scenario
b) the market is less rational than in the Central Case.

To give an indication as to what these sensitivities imply, for commercial waste recycling (the performance parameter most affected by the change in rationality), the Central Case implies a recycling rate of 57% once the tax reaches £80 per tonne. The 'Low Rationality' and 'High Rationality' cases deliver, respectively, 52% and 62% recycling.

Evidently, the above approach does not account for all materials in the commercial waste stream (only those for which we have been able to develop plausible models of the costs of collection), some of which may well be recycled with increasing success in future. For these materials, we have assumed that as the landfill tax increases, so there will be a corresponding reduction in the quantity sent to landfill (modelled through applying a suitable demand elasticity for landfilling waste, the figure used here being -0.5, as used by HMRC in their model of landfill tax), and an associated increase in recycling and non-landfill treatment. In the central case, we have made a simplifying assumption that at levels of tax below £80 per tonne, recycling is still the dominant alternative for managing commercial waste. In other words, we assume that at these levels of tax, most residual waste is still landfilled. The implications of matters being other than is implied by this assumption are discussed in more detail in Section 6.2.

Management of Residual Waste
Regarding residual commercial waste, we also assume that the tax drives some additional material into incineration. The way we have estimated this is to consider the effect of the tax on increasing recycling. A fixed proportion of this figure (in the Central Case, 25%) has been assumed to be diverted into incineration, thereby further increasing the diversion from landfill. The figure of 25% is relatively modest, but reflects the fact that in the Central Case, as described in Section 4.5.1 below, there is assumed to be no cost advantage in using means of managing residual waste other than landfill. This capacity is deemed to come on stream in 2014.

This assumption (regarding the additional quantity of waste being incinerated, as a proportion of that recycled) is flexed in the cases where we consider alternative scenarios for the costs of non-landfill residual waste treatments. This sensitivity analysis is discussed further in Section 4.5.1 and Section 7. Suffice to say that we have modelled alternative Cases to the Central Case in which the costs of non-landfill residual waste treatment are higher and lower than the costs of landfilling, with the Central Case being that non-landfill residual waste treatment costs the same as landfilling.

Industrial Waste
For the industrial sector any remaining landfilled waste is deemed to be in two general categories:

1. First, relatively homogeneous wastes may still be landfilled because no viable economic alternative exists, even with the announcement of the £80 tax; and
2. Second, mixed wastes, the composition of which is assumed to be very similar to commercial type wastes.

Any increases in landfill tax, in the baseline, only have an impact on the latter fraction. The effect is as described for commercial waste above.

Management of Residual Waste
Regarding residual industrial waste, we take the same approach as with residual commercial waste.

Construction and Demolition Wastes
Finally, for the construction and demolition sector increases in recycling are driven using a simple demand elasticity approach. For active wastes still being landfilled, an assessment has been of the extent to which they would be driven from landfill as the tax increases. An elasticity of -0.6 has been used for this waste stream (as in the HMRC model of landfill tax). Of the waste diverted from landfill 80% is assumed to go to recycling and 20% to thermal treatments (of wood for example).

Management of Residual Waste
Regarding residual industrial waste, we take the same approach as with residual commercial waste.

Landfill Directive Targets
Part of the BaU Scenario is to ensure that European targets are met. These include the Landfill Directive targets. These relate to the quantity of biodegradable municipal waste (BMW) landfilled. The revised definition of

municipal waste now being used by the UK has required some re-setting of the relevant targets. These targets were not obviously consistent with the quantity and composition of the commercial waste stream we have used.

We developed an approach to modelling the Landfill Directive targets which was agreed with SG, using data from SEPA as a benchmark. We chose to continue to use the most recent SEPA Waste Data Digest Data (acknowledging that this data may overestimate the total C&I arisings). We devised a methodology that allowed us to calculate BMW using the SEPA data as a benchmark, whilst also using total C&I arisings from the Waste Data Digest. Table 5 describes our approach.

Table 5: Landfill Directive Targets - Methodology

Variable	Source	Formulae	Notes
Step 1: Tonnes Landfilled			
Total waste landfilled	Quarterly landfill returns	X	This is a known figure we have for 2008.
Total household waste landfilled	Waste data digest	Y	
Total commercial waste landfilled	Waste data digest + treatment assumptions	C	
Total industrial waste landfilled	Waste data digest + treatment assumptions	I	
% of commercial waste classified as municipal waste	Estimate	A	As it is likely that the waste data digest over estimates the total C&I waste arisings these percentage values are lower than we would expect. The model is designed in such a way that if the business waste survey that is being undertaken confirms this it will simply be a case of reviewing these assumptions to recalculate. This allows us to use the published waste data digest data for this stage of the modelling but also for the user, Scottish Government, to adjust the modelling if the total C&I waste arisings are found to be significantly less than the 2006 survey suggested.
% of industrial waste classified as municipal waste	Estimate	B	
Total waste landfill subject to landfill directive target	Calculated	X = Y + (A*C) + (B*I)	This calculation ensures that our modelled total tonnes landfilled equals the calculation made using the EWC chapter codes. This gives us the factors we need to make the calculation for future years.
Step 2: Tonnes of BMW sent to Landfill			
Total BMW Landfilled	Calculated	Data in table 2 (below) applied to composition of residual waste.	Following the calculation of the total tonnes landfilled subject to the landfill directive above we then calculate the tonnes of biodegradable waste sent to landfill. We apply a percentage biodegradability to each category of residual waste (Table 6). This percentage is known for the majority of categories, and is reflected

Variable	Source	Formulae	Notes
			below. The 'other' category is used as a variable to benchmark our total tonnes of BMW to landfill against the total BMW figures calculated from the EWC chapter codes in the data sent to us. This results in a biodegradability of 20% in the 'other' category.

Table 6: Landfill Directive Targets - Methodology

Waste Category	% Biodegradability
Paper and card	100.0%
Dense plastic	0.0%
Plastic film	0.0%
Glass	0.0%
Ferrous metal	0.0%
Non-ferrous metal	0.0%
Textiles	50.0%
Wood	100.0%
Food waste	100.0%
Green waste	100.0%
Furniture	50.0%
WEEE	0.0%
Other	20.0%
Incinerator Ash	0.0%
Soil	0.0%
Aggregate	0.0%
Insulation & Gypsum based materials	0.0%
Hazardous site waste	0.0%

Using this approach, and assuming the above changes and responses, under BaU, the Landfill Directive targets are met. This is illustrated in Figure 3. In all years, the quantity of biodegradable municipal waste (BMW) landfilled is below the target set under the Landfill Directive. The underlying data are given in Table 7.

Figure 3: Performance against Landfill Directive Targets – Business as Usual

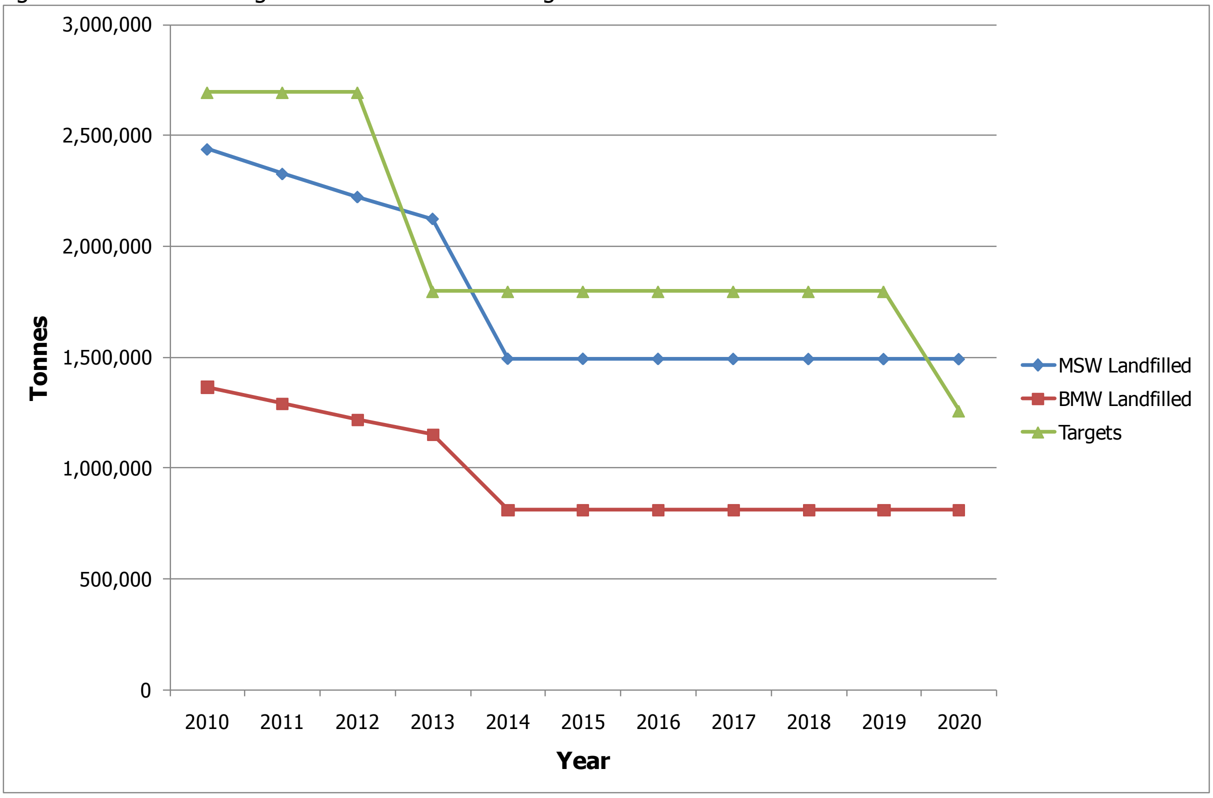


Table 7: Performance against Landfill Directive Targets – Business as Usual

	2010	**2011**	**2012**	**2013**	**2014**	**2015**
MSW Landfilled	2,439,621	2,328,657	2,224,305	2,125,651	1,493,431	1,493,090
BMW Landfilled	1,364,306	1,289,052	1,217,657	1,149,462	809,876	809,794
Targets	2,696,584	2,696,584	2,696,584	1,797,723	1,797,723	1,797,723
	2016	2017	2018	2019	2020	
MSW Landfilled	1,492,751	1,492,415	1,492,082	1,491,750	1,491,421	
BMW Landfilled	809,712	809,631	809,551	809,471	809,391	
Targets	1,797,723	1,797,723	1,797,723	1,797,723	1,258,406	

Waste Framework Directive Targets

The BaU Scenario was intended to be one where the targets in the revised EU Waste Framework Directive were met. These are set out as follows:

> *In order to comply with the objectives of this Directive, and move towards a European recycling society with a high level of resource efficiency, Member States shall take the necessary measures designed to achieve the following targets:*
> *(a) by 2020, the preparing for re-use and the recycling of waste materials such as at least paper, metal, plastic and glass from households and possibly from other origins as far as these waste streams are similar to waste from households, shall be increased to a minimum of overall 50 % by weight;*
> *(b) by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be increased to a minimum of 70 % by weight.*

It is important to recognise that the first of these targets is ambiguous (does this apply to each material individually, or to the collective of the materials?), whilst the second target does not apply to all construction and demolition waste, as traditionally defined. For the first, we assume the target applies to the group rather than to each material individually. For the construction and demolition waste target, we have manipulated the available data to ensure the calculations are made on the basis of the correct figures (i.e., as indicated above, excluding wastes falling under category 17 05 04).

In the BaU, the 50% (tonnage-based) target is met for the materials as a group and it is just exceeded for household waste as a whole. It is met for all individual materials other than plastics, for which the material reaches a 31% recycling rate. It is worth noting that a 50% target specifically for plastics is quite challenging. In Scotland, the composition of household waste includes 6% as dense plastics and 3% as plastic film. Household films may not be so easy to recycle (and they are likely to increase the costs of recycling). If the 50% target is to be achieved largely from dense plastics, then the implied capture rate required to meet a 50% target for plastics recycling is 75% (because the dense plastics account for around two thirds of plastics in the waste composition).

The C&D waste target is exceeded by some margin in the BaU Scenario, reaching a level of around 90%.

4.4.2. Zero Waste Plan

In addition to the policy drivers considered above under the BAU baseline, there are targets in the ZWP, and regulations being consulted upon which will give effect to the ZWP. The targets include:[45]

1. A carbon based target system for re-use and recycling. Guided by Scottish Government, we have assumed the targets for **all** waste in 2025 will be the same as the weight based targets for household waste stated in the ZWP.[46] For household waste only, interim targets also apply. However, weight based targets will still be calculated up until the introduction of the carbon metric in 2013. The targets are, therefore, as follows:
2. 40% recycling/composting and preparing for re-use of waste from households by 2010;
3. 50% recycling/composting and preparing for re-use of waste from households by 2013;
4. 60% recycling/composting and preparing for re-use of waste from households by 2020;
5. 70% recycling/composting and preparing for re-use of waste from households and all other waste streams (separately) by 2025.

   It should be noted that we have not 'forced' the model to meet the 2010 weight-based recycling target for household waste since this date has already passed. The focus has been on the carbon-based targets in the later years.
6. Maximum of 5% of waste to landfill by 2025 for all Scotland's wastes. It is not clear exactly how this will be implemented / enforced. It is not yet clear, for example, whether residues from MRFs, residues from residual waste treatment facilities, ashes (from thermal processes, waste- and non-waste-related), etc., are to be included or not. Given the lack of final decisions, we have, by and large, sought to ensure that the pre-treatment requirement is respected. Ultimately, how the residual waste treatment market unfolds is likely to be determined by how the 5% figure is implemented (if, indeed, it is not to be considered more of an aspirational target).

As far as the Regulations are concerned, there are 5 Regulations of significance:[47]

1) *Source segregation and separate collection of specific materials from 2013 – the intention is that a requirement be introduced to collect the undernoted wastes separately:*

   A) Food waste, from households and business sectors, such as commercial kitchens, hospitality sector, food retailers and manufactures;

   B) Paper/card, metals, plastics, textiles and glass from all sources.

   We assume these will be implemented much as the 'requirements to sort' were assumed to be implemented in our earlier work on landfill bans. However, importantly, we assume that the 'requirement to sort' is implemented in such a way that the nature of the sorting infrastructure provided by local authorities is such that systems are efficient, and likely to deliver high captures (which does not, incidentally, demand a full specification of service, rather, a set of principles);[48]

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[45] *Scottish Government (2010) Scotland's Zero Waste Plan, Edinburgh: The Scottish Government.*

[46] *Scottish Government (2010) Scotland's Zero Waste Plan, Edinburgh: The Scottish Government.*

[47] *Scottish Government (2011) Regulations to Deliver Zero Waste: A Consultation on the proposed Zero Waste (Scotland) Regulations 2011, available at: http://www.scotland.gov.uk/Publications/2011/02/09135833/0*

[48] *See Eunomia (2010) Feasibility of Landfill Bans Research, Final Report for WRAP, March 2010*

2) *A ban on the landfilling of source segregated wastes collected for recycling for the same materials described above from 2015.*
We have assumed that this has relatively little effect – once materials are segregated for recycling, it makes little sense to pay to landfill them when the materials have a value. This type of clause is likely to become relevant only where:

- the system for collection / engagement with them is so poor that loads have to be rejected from reprocessors. This, therefore, suggests a need for quality collection systems; and
- the market for materials collapses, leading to issues associated with loss of markets, and potential over-supply in the market

Neither of these is especially straightforward to deal with in a high level modelling exercise such as this. We have not incorporated anything specific in the modelling to represent this;

3) *A ban on mixing separately collected recyclable materials from 2015.*
This regulation is again difficult to model in a high level exercise as this. There are likely to be similar reasons why this would be unlikely to happen on a widespread basis (as discussed above), and much will depend upon the final form of the Regulation as to if, and if so, how, any facilities are affected by this;

4) *Restricting Inputs to Energy from Waste Facilities (Incineration, Gasification or Pyrolysis).*
This regulation is still in development. The aim, as we understand it, is to have a 'second bite at the cherry' in respect of recycling. In essence, it requires some form of pre-treatment of waste prior to, or during, the process of its being combusted, or biologically treated. Materials of focus are likely to be plastics and metals. Two broad families of process may be relevant:

A) Thermal processes, which require sorting either as a separate step prior to processing, or sorting as part of a fuel preparation process. It should be noted that where plastics are included in this requirement, then quite apart from the recycling benefits which may be obtained, the biomass content of the remaining feedstock would be expected to be enhanced in line with the efficiency of separation of plastics. It should also be noted that some thermal processes consider the issue of plastics separation anyway as a means to reduce the chlorine content of the feedstock so as to reduce the level of corrosion experienced; and

B) MBT / MHT systems, where no thermal process is involved, and where the recycling element is integrated into the process, and where the remaining materials may be sent to a range of different facility types, including landfill.

For the purposes of this work, we have not modelled a 'specific' treatment facility of combination thereof. Rather, we have used a synthetic cost and environmental performance to reflect the costs and performance that might be expected of residual waste treatments where they are required to operate in line with the Regulations as loosely described above.

5) *A ban on the landfilling of biodegradable wastes from 2017.*
This regulation is also still in development. Our understanding from SEPA and the Scottish Government is that this is now unlikely to be implemented through the mechanism suggested in the Consultation on the Regulations. For the purpose of this report, and without prejudice to the nature of a decision which is yet be made, we have assumed the ban would effectively be implemented through the following measures:

A) A clear 'threshold' being established, in terms of respirometry, which, for the purposes of the measure, denotes the level at which waste is no longer to be considered as 'biodegradable';

B) A certification scheme being introduced for MBT plants which seek to meet the threshold;

C) A requirement to specify on the Waste Transfer Notes whether waste had been pre-treated at authorised facilities or was otherwise deemed to satisfy requirements; and

D) Landfill operators would be required to inspect Waste Transfer Notes to check that the waste is compliant. Any 'black bag' type waste would be rejected and directed to either incineration or accredited MBT plants.

This measure is discussed in somewhat more detail in previous work by ourselves.[49] The ban on biodegradable wastes going to landfill is modelled similarly for all sectors by ensuring that, in 2017, all residual waste, less 5% of material (other than where the nature of the material suggests this figure should be higher), is sent to pre-treatment plants such as MBT or thermal processes. If the processes generate energy through a thermal element, then some effort must have been made to remove recyclables before the thermal treatment begins.

[49] *Eunomia (2010) Feasibility of Landfill Bans Research, Final Report for WRAP, March 2010*

The following sections describe how different waste streams are assumed to be affected in the ZWP Scenario.

Note that in the Central modelling case, the timing of the Regulations is as stated above. Some consideration is given below to how the costs and benefits may change with a change in the timing of the introduction of the Regulations.

Household Waste

The key changes relative to BaU, in terms of recycling, are as follows.

1) At HWRCs / Bring sites (principally assumed to be HWRCs, with the role of Bring assumed to be diminishing over time as kerbside systems develop):
   the recycling performance of the HWRCs is assumed to increase over time. This will be necessary in order to meet longer-term ZWP targets, so we have raised the capture of a range of materials over the period to 2025. There is reason to believe that the relative level of priority accorded to collection of different materials may be influenced by the weightings implied by the carbon-metric. Textiles, in particular, are likely to be targeted for recycling with a growing intensity. It remains to be seen, however, how effective the recycling (as opposed to recovery) of textiles can be, and much may depend upon how 'textiles' are classified. In general, the performance against the carbon metric might depend upon how waste composition analyses are conducted (which materials / products are assigned to which categories). The modelling of costs follows the same approach as in the BaU.
2) For kerbside collected waste, the following approach is taken:

i. Local authority collection services improve in their design, efficiency and their performance;
ii. The cap which was applied[50], in respect of kerbside recycling performance, to those authorities with considerable residual waste treatment capacity either planned or already in place, is relaxed;
iii. The captures of the materials being targeted reaches levels as set out in previous work (see Table 8);[51]
iv. The collection costs rise as a result, but with a decline in residual waste requiring to be managed as a result; and
v. The change in costs is based upon the kerbside modelling exercise carried out for this project, and reflects the relative proportions of Urban, Rural and Mixed authorities.

3) Regarding organic waste treatment, we have assumed that the requirement to sort food leads to an increase in the quantity of separately collected food that is sent for anaerobic digestion (and the carbon metric increases the likelihood that this will be the case);
4) Regarding residual wastes, we have assumed that all kerbside collected waste is no longer landfilled beyond the year in which the requirement to pre-treat waste is assumed to take effect. We assume 6% of HWRC / Bring waste continues to be landfilled as we believe some residuals from such sites will not be appropriate for treatment because of their nature and / or physical size (or would be rejected, in any case, at the facility, e.g. mattresses). We effectively assume that existing incineration capacity (that already in place) continues to operate. Evidently, these may have to modify themselves appropriately (for example, through the addition of front-end sorting equipment), but given the relatively small tonnage to which this would apply, we have not modelled any change in costs (not least since it remains uncertain as to what these might be, pending final decisions regarding what pre-treatment of residual waste would be required prior to incineration).

[50] *The use of caps is explained in section 4.4.1.*

[51] *For details behind the proposed figures, see Eunomia (2010) Feasibility of Landfill Bans Research, Final Report for WRAP, March 2010*

Table 8: Maximum Household Recycling Rates under ZWP

Weight Based Recycling Rate	Recycling Rate under ZWP
Paper and card	85%
Dense plastic	45%
Plastic film	15%
Glass	90%
Ferrous metal	75%
Non-ferrous metal	75%
Textiles	60%
Food waste	55%

Commercial Waste
For commercial waste, we have assumed that captures of the dry recyclables targeted by the requirement to sort, and of food waste, increase to levels suggested in previous work on landfill bans (see Table 9).[52] These captures lead to increases in recycling rates. From the cost curves developed above, it is possible to estimate the additional costs of this additional recycling. In the central case, where the rationality in the commercial waste collection market is assumed to be moderate, not all additional recycling incurs additional costs. However, to achieve the levels of recycling implied by the ZWP does incur some increases in cost over and above BaU levels.

As for household waste, we assume that existing capacity for incineration continues to be used, albeit in a (perhaps) amended form. All other residual waste, less 5% of total, is deemed to go to non-landfill residual waste treatments.

Table 9: Maximum Commercial Recycling Rates under ZWP

Weight Based Recycling Rate	Recycling Rate under ZWP
Paper and card	92%
Dense plastic	67%
Plastic film	57%
Glass	90%
Ferrous metal	90%
Non-ferrous metal	90%
Textiles	81%
Food waste	70%

Industrial waste
For industrial waste, we have assumed that as with commercial waste, captures of the dry recyclables targeted by the requirement to sort, and of food waste, increase to levels suggested in previous work on landfill bans (see Table 10).[53] We assume that since much of the industrial waste is already being treated in various ways that the 'above BaU' recycling resembles 'commercial waste' so the same costs apply. Hence, collection costs are higher than under the BaU Scenario.

[52] *For details behind the proposed figures, see Eunomia (2010) Feasibility of Landfill Bans Research, Final Report for WRAP, March 2010*

[53] *For details behind the proposed figures, see Eunomia (2010) Feasibility of Landfill Bans Research, Final Report for WRAP, March 2010*

As for commercial waste, we assume that existing capacity for incineration continues to be used, albeit in a (perhaps) amended form. All other residual waste, less 5% of total, is deemed to go to non-landfill residual waste treatments.

Table 10: Maximum Industrial Recycling Rates under ZWP

Weight Based Recycling Rate	Recycling Rate under ZWP
Paper and card	90%
Dense plastic	80%
Plastic film	50%
Glass	95%
Ferrous metal	92%
Non-ferrous metal	95%
Textiles	80%
Food waste	95%

Construction and Demolition Waste

For C&D wastes, we have assumed that as with C&I waste, captures of the dry recyclables targeted by the requirement to sort increase to levels suggested in previous work on landfill bans (see Table 11).[54] There are relatively few data sources regarding the cost of recycling specific C&D waste streams. In the absence of better data, we have based the costs of achieving higher rates ((than under BaU) through a basic 'skip-based' model of C&D collections.

Table 11: Maximum C&D Recycling Rates under ZWP

Weight Based Recycling Rate	Recycling Rate under ZWP
Paper and card	95%
Dense plastic	75%
Glass	90%
Ferrous metal	90%
Non-ferrous metal	95%

The collection cost of collection of C&D waste has been based on the cost of skip hire. We have based the costs on the hire of a 6 metre cubed skip, containing between 1 and 3 tonnes of material, to be in the order of £150 - £250. This data is based on research carried out during a project for the Welsh Assembly Government.[55] This study found that the cost of C&D skip hire depends upon:

- Haulage costs (time to and from depot / destination of waste);
- Whether the material being collected is mixed or segregated;
- Where segregated, the nature of the material (and hence, the value obtainable for the material net of transport);
- Where mixed:
    - The nature of the material (density, composition etc.);
    - The location of the receiving destination and the fate of the material once it arrives. This is important since:

[54] *For details behind the proposed figures, see Eunomia (2010) Feasibility of Landfill Bans Research, Final Report for WRAP, March 2010*

[55] *Eunomia (2010) Site Waste Management Plans Cost Benefit Analysis, Final report for the Welsh Assembly Government*

- Increasingly, mixed waste skips will not, in general, be sent direct to landfill but will be subjected to some form of sorting operation; and
- The efficiency of the sorting operation (and the nature of the mixed waste) will determine the likely quantity that is ultimately sent for disposal, and hence, the exposure of the overall load to landfill tax.

These costs will change in future for mixed waste skips, with the skip hire costs being affected by the unsorted fraction of waste which still needs to be landfilled. We have assumed that once the tax reaches £80 per tonne, a mixed skip sent for recycling will typically be sorted such that 75% of the material is recycled, re-used or recovered (as material, rather than energy). This type of segregation rate is not excessive by international standards and is used as an average rate for Scotland in future in the absence of better knowledge of the country-wide performance of such facilities (either now, or in future).[56] Hence, this remains an assumption, and reflects performance which might actually be exceeded in future.

As with C&I waste, we assume that existing residual waste treatments continue to be used, albeit in a (perhaps) amended form. For all other residual waste, we suspect that since this originates from C&D activity, much of this might not be so well-suited for non-landfill residual waste treatments. We therefore assume a proportion of wood is sent to thermal facilities, but that the bulk of the residual waste (which, as both Figure 10 and Figure 11 below indicate, is a rather small proportion) is still sent for landfill.

4.4.3. EU Targets

Note that under the ZWP scenario, we still consider whether the following European Union Directive targets are met:

- EU Landfill Directive targets for BMW to landfill.
- EU WFD Targets for paper, metals, plastics and glass.

As might be expected, because under BaU these are already met, then they are also met under the ZWP Scenario. Plastics still do not meet the 50% target. Depending on the implementation of the requirement to sort plastics, then given plastic films' very small contribution (around 2%) to the total carbon embodied in waste as measured using the carbon metric, local authorities may not obviously target this material for collection.

4.4.4. Recycling Targets

It should be noted also that as regards the ZWP recycling targets, then on the basis of the composition data we are working with, it looks less than straightforward to meet the 70% target for household waste based on the Carbon Metric. Much depends, as discussed above, on the true composition of waste generated by households in specific contexts. The massive contribution (around 37%) accounted for by textiles in the embodied carbon as measured by the carbon metric makes this a key material for local authorities in particular. As noted above, in previous work on landfill bans, and on the basis of a brief review of other country performance, we deemed it unlikely that recycling / re-use rates for textiles from household waste would exceed the 60% mark.[57] To do this will require substantial effort from the local authorities (whose current textiles recycling rate appears to be around 16%).

In addition, we note also that in work for Wales, we felt it likely to be difficult to meet the sorts of level of performance being envisaged in the absence of some form of incentive to encourage households to engage with the services being provided.[58]

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[56] *In the Netherlands, recyclable/reusable wastes from construction and demolition have been banned from landfill since 1997. These wastes include masonry & concrete rubble, metals, untreated wood, paper and cardboard etc. Currently, about 95% of all C&D waste is recovered. In Germany, the 'Commercial wastes Ordinance, 2002' includes minimum requirements for re-treatment facilities, covering some construction and demolition wastes. To facilitate high levels of recovery, Section 8, Paragraph 1 of the Ordinance specifies a number of wastes which should be held, stored, collected and hauled for recovery, separately. These wastes are: (i) glass, (ii) plastic, (iii) metals, (v) concrete, bricks, ceramics (or a mixture of these). The recovery quota is a minimum of 85% by weight over a calendar year, and applies to the wide range of waste streams mentioned in the Annex (not containing, or contaminated by dangerous substances).*

[57] *Eunomia (2010) Feasibility of Landfill Bans Research, Final Report for WRAP, March 2010.*

[58] *Eunomia (2008) Scoping New Municipal Waste Targets for Wales, Report for the Welsh Local Government Association and the Welsh Assembly Government.*

4.5. Treatment Cost Modelling

For the purpose of this work, we have sought to model the costs and revenues pertaining to treatment facilities on the assumptions that:

i. The costs which apply are those that would apply if all biowaste and all residual waste was being treated in Scotland (effectively, a closed economy situation); and
ii. The revenues from recyclable materials are based upon medium-term averages, reflecting what might be expected over a five- to ten-year horizon. [59] The revenues used are shown in the final column of Table 12 below. The Table also shows values used in other recent projects, as well as evidence from WRAP's Material Pricing Report on the differentials which appear to have been in place between Scotland and England over the past 4 years. These have influenced our setting of the prices for all materials other than paper and board where the differential appears high relative to what can be readily explained through the operation of the market.

It might be noted that if the material prices used in the study were those that prevail today, then the costs of the move from BaU to ZWP would be lower than is suggested in this document.

Any, and all, cross border movement of waste (in particular residual waste flows to and from England which have the potential to alter the quantities and costs of Scottish waste treated by either landfill or incineration) are not accounted within this study. The effects of relaxing these assumptions, particularly relevant regarding residual waste treatment, are discussed in Section 6.2 below.

There are a number of taxes and subsidies that apply to the modelled infrastructure. Note that these are included in our modelling reflecting the discussion at Section 3.1 above:

- *Landfill Tax, Standard Rate* **-** The standard rate of Landfill Tax is currently at a level of £56 per tonne, and will increase at the rate of £8 per tonne per year until it reaches £80 per tonne in 2014/15.[60] The government has not indicated its policy on landfill tax beyond this. For the purpose of this analysis, we assume that the tax increases to £80 per tonne, in nominal terms, and that thereafter, the tax rate remains constant in real terms (i.e. its nominal rate increases in line with inflation once the £80 per tonne level is reached). We therefore adjust the nominal rates of landfill tax to real 2010 prices by applying a deflator of 2.5%. This was consistent in the earlier stages of the work with the Office for Budget Responsibility's inflation forecast over 2011-15. The average forecast over the period has since been revised upwards to reflect higher than expected inflation in 2011. However, inflation is still forecast to return to 2% in later years.
- *Landfill Tax, Lower Rate* **-** The lower rate of Landfill Tax stood at £2.00 per tonne for many years before it was increased, in 2008, to £2.50 per tonne. The 2010 Budget Report stated that this lower rate applying to inactive wastes will be frozen at £2.50 per tonne. Therefore, the lower rate tax is assumed to remain constant in nominal terms (from 2010) over time, i.e. it declines, over time, in real terms.
- *Revenue from Electricity Sales* - The wholesale price for electricity, 7.2p/kWh, is the central value contained within the most recent Updated Energy Projection published by DECC.[61] The nature of Power Purchase Agreements and the quality of the deal they deliver for generators varies considerably. In our modelling, we have assumed that the generator benefits from a proportion of the wholesale price, with the default figure set at 80%. The generator thus receives 5.8p/kWh. The modelling does not link to 'year on year' costs for energy prices so the energy price is effectively assumed to be constant in real terms;

[59] *This means that prices might not resemble those which one finds if one looks up material prices today. The prices used constitute working assumptions on average levels of prices which were deemed likely to be obtained over the period of the study. The prices for textiles are towards the lower end of the prices typically quoted by rag merchants. The value used here is a conservative estimate of what would prevail for material whose quality is unlikely to match that of charity shops, or well operated bring banks.*

[60] *HM Treasury (2010) Budget 2010, http://www.hm-treasury.gov.uk/d/junebudget_complete.pdf*

[61] *DECC(2010) Energy and emissions projections webpage, Table E: price assumptions, http://www.decc.gov.uk/en/content/cms/statistics/projections/projections.aspx*

Table 12: Materials Prices Used in the Modelling

Material	WAG Collections[62]	WAG CBA[63]	WRAP Material Values[64] used in SQWenergy Report[65]	Scotland Prices Relative to England (average difference over 2-4 years)[66]	Values Used
Paper and card	News and Pams - £70 Card - £65	News and Pams - £70 Card - £65	News and Pams - £55 Card - £59	-£22	£65
Dense plastic	Mixed - £123	Mixed - £30	Clear PET - £156 Mixed HDPE - £172	+£13	£130
Mixed Glass	Mixed - £0	N/A	£16	-£7	£0
Colour Separated	£16	£16		-£1	£15
Ferrous metal	£89	£89	£82	-£7	£82
Non-ferrous metal	£664	£664	£770	-£4	£650
Textiles	Commingled - £174 Kerbside Sort - £284	Commingled - £110 Kerbside Sort - £284	N/A	N/A	£200

[62] *Eunomia Research & Consulting, Resource Futures, and HCW Consultants (2011) Kerbside Collections Options: Wales, Report for WRAP, January 2011*

[63] *Eunomia Research & Consulting (2011) Economic Assessment of the Welsh Assembly Government's Collections, Infrastructure and Markets Sector Plan, Report for WRAP, February 2011*

[64] *WRAP (2009) WRAP Material Pricing Update, http://www.wrap.org.uk/media_centre/press_releases/wrap_materials.html, Date Accessed: 21 Feb. 2011*

[65] *SQWenergy (2010)* Meeting Scotland's Zero Waste Targets: Assessing the Costs Associated with New Waste Management Infrastructure*, Report for The Scottish Government, 23 April 2010*

[66] *Calculations based on information provided by Pete Mitchell, WRAP, based on WRAP Material Pricing Reports.*

- *Revenues from Heat Sales* **-** A value for heat sales of £30/MWh is given by Ernst & Young, based on the company's proprietary data, in a review for BERR/Defra of the initial business case for renewable heat.[67] Work by Jacobs for SEPA used a lower figure of 1.5p/kWh (£15/MWh).[68] In this study, whereby facilities would typically export heat rather than displace alternative fuel costs, a heat offtake price of £15/MWh has been assumed. As with electricity prices, treatment prices are not linked to a year on year change in revenues for heat sales. Implicitly, these are assumed to increase in line with inflation (constant in real terms);
- *Renewable Heat Incentive* **-** The UK Government has announced the forthcoming implementation of the Renewable Heat Incentive (RHI). [69] Details of the mechanism, including tariff levels and funding approach were announced in March 2011, and subject to Parliamentary approval, the first phase of the scheme will be launched in summer 2011. This first phase will provide long-term tariff support targeted at the non-domestic sector. As part of this first phase, the Government will also introduce 'Renewable Heat Premium Payments' for the domestic sector, to subsidise the cost of installing renewable heating systems. Approximately £15 million has been allocated for these Premium Payments. The second phase, including long-term tariff support for the domestic sector will be introduced in 2012. RHI payments will be funded from general Government spending, not through the previously proposed RHI levy. The tariff for biomethane injection into the grid at all scales will be 6.5p/kWh and for biogas combustion (except for landfill gas) will be 6.5p/kWh for installations up to 200kWth. For biomass, the level of support varies based on the installed capacity. In the case of energy from waste (CHP), RHI support will be paid on the biomass content, taken to be 50% unless proven otherwise. The level of support, for installations of less than 200kWth is set at 7.6p/kWh for Tier 1, and 1.9p/kWh for Tier 2. Tier 1 applies annually up to the Tier Break, which is installed capacity multiplied by 1,314 peak load hours. Tier 2 applies for heat generation above the Tier break. For installations of 200kWth and over but less than 1,000 kWth, the level of support is 4.7p/kWh for Tier 1, and 1.9p/kWh for Tier 2. For installations of 1,000kWth capacity and over, the support is set at 2.6p/kWh for all heat generation.
- *ROC Values* **-** We use the weighted average of ROC values for 2010, which is £47.65/MWh.[70] As with electricity revenues, we have assumed that 80% of the ROC value (£38.12/MWh) is realised by the generator in the default situation. Relevant technologies within the modelling, and their banding for the purpose of generating ROCs, are Landfill Gas (0.25 ROCs/MWh), Good Quality CHP (1 ROC/MWh for the biomass fraction), gasification (2 ROCs/MWh) and AD (2 ROCs/MWh).
- *Levy Exemption Certificates for Good Quality CHP* **-** Fuel used by energy from waste projects qualifying as Good Quality CHP (certified via the CHP Quality Assurance Programme [CHPQA]) is exempt from the Climate Change Levy (CCL). Electricity from new renewable energy such as anaerobic digestion is also exempt from the levy. Energy from Waste projects that do not meet the CHPQA standards are not eligible.[71] Under the CCL, electricity is currently (with effect from 1 April 2009) subject to a rate of £4.70/MWh.[72] We assume for modelling purposes that 80% of the value (£3.76/MWh) is realised by the generator.

These taxes and subsidies are reflected in the Unit Costs discussed below. [73]

4.5.1. Unit Costs

The treatment modelling uses the mass flows described in Section 4.2 to calculate the treatment cost of collected material. The costs are presented in two ways in this report:

i. In the first instance, and for the majority of the report, we highlight the 'annualised' costs of a given facility. This takes into account that whilst facility developers will have to invest a capital sum upfront for the facility and its construction, the users of facilities are typically charged a unit cost (or gate fee)

[67] *Ernst & Young (2007)* Renewable Heat Initial Business Case*, Report to Defra/BERR, 20 September 2007*

[68] *Jacobs (2008) Development of a Policy Framework for the Tertiary Treatment of Commercial and Industrial Wastes: Technical Appendices, Report for SNIFFER / SEPA, March 2008.*

[69] *DECC, 2011. Renewable Heat Incentive. Available at http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/policy/renewableheat/1387-renewable-heat-incentive.pdf (accessed April 2011)*

[70] *Non-Fossil Purchasing Agency website, Average ROC prices webpage, http://www.e-roc.co.uk/trackrecord.htm*

[71] *Ofgem (2009) CCL:CHP Exemption, Ofgem website, available at http://www.ofgem.gov.uk/Sustainability/Environment/CCLCHPEx/Pages/CCLCHPEx.aspx*

[72] *HMRC (2008) Budget 2008, Climate Change Levy: Rates, http://www.hmrc.gov.uk/budget2008/bn84.pdf*

[73] *It is worth noting that the future of renewable obligations is unclear. There are several proposals currently being consulted on reviewing support mechanisms applied to energy markets, some of which suggest the renewable obligations will be replaced by other mechanisms. Since a decision is not due until 2012 we have modelled the renewable obligations being in place for the duration of the study period.*

which means that they themselves do not have to find the money to make the capital investment. There may be exceptions to this rule (as, for example, with local authorities borrowing to finance facilities, or with businesses purchasing facilities for 'on-site' solutions);

ii. In the second, we present the total investment required to build new facilities (see Section 5.6). These costs are not 'additional to' the costs presented in annualised form, but represent some of these costs in a different form. They seek to demonstrate the magnitude of the investment programme required in future to deliver the different outcomes.

For this reason, in Table 13, we have shown two figures:

1. The first is the assumed unit cost for the facility. For the biowaste treatment facilities, these have been based upon the results from the latest WRAP Gate Fees Survey (as yet unpublished) which is carried out by Eunomia on behalf of WRAP. For residual waste treatments, the approach deserves some explanation. We have not sought to anticipate what type of residual waste treatment might be used to deliver the movement away from landfilling of the unrecycled waste. As such, a range of different systems could, in principle, be used, the costs for which have the potential to vary considerably (and not just with scale). What matters in this analysis is what the costs for dealing with residual waste might be, irrespective of what that technology might be (we are not in a position to second guess this). We have therefore modelled three different cases. The first (Central Case) is where the costs of treating residual waste are the same as landfilling. We have modelled two other cases where the costs are high and lower than in this Central Case;
2. The second (in the final column) is the unit capital cost assumed for a given facility type. These have been based on previous work by Eunomia for WRAP (which was peer reviewed). [74] For residual waste treatment, we use a figure somewhat below what we might expect for incineration (typically of the order £600 per tonne), but above that for some MBT configurations, reflecting the possibility of a mix of treatments coming forward (these typically having lower unit capital costs). This is an estimate which is intended to give an indication of the likely capex requirement rather than a hard and fast answer.

The Figures in Table 13 are given in real 2010 terms. A simplifying assumption is that these costs remain constant in real terms over the period we are modelling. Clearly, this might not hold good, but it is difficult to make clearly supportably alternative assumptions for the period going forward.

The figures for sorting require some explanation. The costs used for household waste collection exclude sorting (at MRFs) and revenues (so comingled systems have a much lower cost than kerbside sort ones). The model then calculates material revenues for all recycled materials. It then has to calculate a cost for MRF sorting for the material, with the cost calculated as though revenues were set to zero. Using WRAP's MRF model, we estimate this to be of the order £60, including disposal of rejects, once landfill tax reaches its 2014 level.

In order to reflect the Scottish market for landfill, a more traditional 'gate fee' approach has been used. We have assumed an average gate fee for landfill based on known local authority contracts and telephone interviews with landfill operators regarding market prices (the figures are shown in Table 14 and are expressed in real terms). The pre-tax gate fee figures are, of course, an average, and it might be expected that gate fees would be lower in the Central and Southern parts of Scotland than in the North. The relevant landfill tax is then added to this gate fee.

[74] *See Appendix 11 in Eunomia (2010) Feasibility of Landfill Bans Research, Appendices to Final Report for WRAP, March 2010.*

Table 13: Unit Treatment Costs Modelled (real 2010 terms)

Treatment	**Unit Cost (see Notes) (£/ tonne)**	**Notes**	**Unit Capital Cost (£/ tonne)**
Non-landfill Residual Waste Treatment	Central Case £88 Low Case £77 High Case £95	In the central case, these are assumed to be the same as the costs of landfill plus tax. In the low case, the figure used lies slightly below the figure from the latest WRAP Gate Fees survey for a 200-300kt incinerator, and reflects a view that relatively few larger facilities are likely to be built in Scotland The high case reflects what we feel could be representative of future costs for MBT and incineration solutions	£450 (note – this is not related to any specific treatment since we make no assumption about which treatments may be used)
Open Air Windrow	£24	Unit cost from latest WRAP Gate Fees Survey	£75
In-Vessel Composting	£43	Unit cost from latest WRAP Gate Fees Survey	£165
AD (Electricity only)	£44	Unit cost from latest WRAP Gate Fees Survey	£300
MRF	£60	MRF with glass, with cost net of material revenue at prices given in Table 12 (note that this is not a gate fee as typically quoted, and that the costs are quoted before revenue).	£75

Table 14: Unit Landfill Costs Modelled (note costs are in real 2010 terms)

Treatment	**Gate Fee (£ per tonne)**	**Landfill Tax (£ per tonne, 2014)**	**Notes**
Landfill (Inert)	£0	£2	Assumed that gate fee for inert landfill is zero as this reflects the current situation in the Scottish market and is not expected to change in the medium term. Tax deflated at 2.5% per annum
Landfill (Non-hazardous)	£16	£72	Tax deflated at 2.5% per annum (see main text)

4.6. Cost of Regulations

In addition to a change in treatment and collection costs there will be a cost of implementing the regulations, and these have been estimated through our understanding of the regulations, as stated in the consultation document.[75] Though this work is not a detailed impact assessment a similar approach has been taken. Costs and benefits have been based upon estimates of the time involved for businesses and regulators to implement and enforce the relevant regulations, and are derived from a number of assumptions. Relevant actors considered include SEPA, the Scottish Government, local authorities, business esand the waste management industry.

[75] *Scottish Government (2011) Regulations to Deliver Zero Waste: A Consultation on the proposed Zero Waste (Scotland) Regulations 2011, available at: http://www.scotland.gov.uk/Publications/2011/02/09135833/0*

5. Results

This Section presents the key results from the analysis and discusses the key factors of interest.

5.1. Waste Arisings and Management

Figure 4 and Figure 5 show the pattern of household waste management under BaU and ZWP, respectively. The ZWP scenario shows higher rates of recycling / composting / AD, and higher rates of non-landfill residual waste treatment. This leads to lower rates of landfilling.

The raw data are presented in Table 15.

Figure 4: Household Waste Arisings and Management – Business as Usual

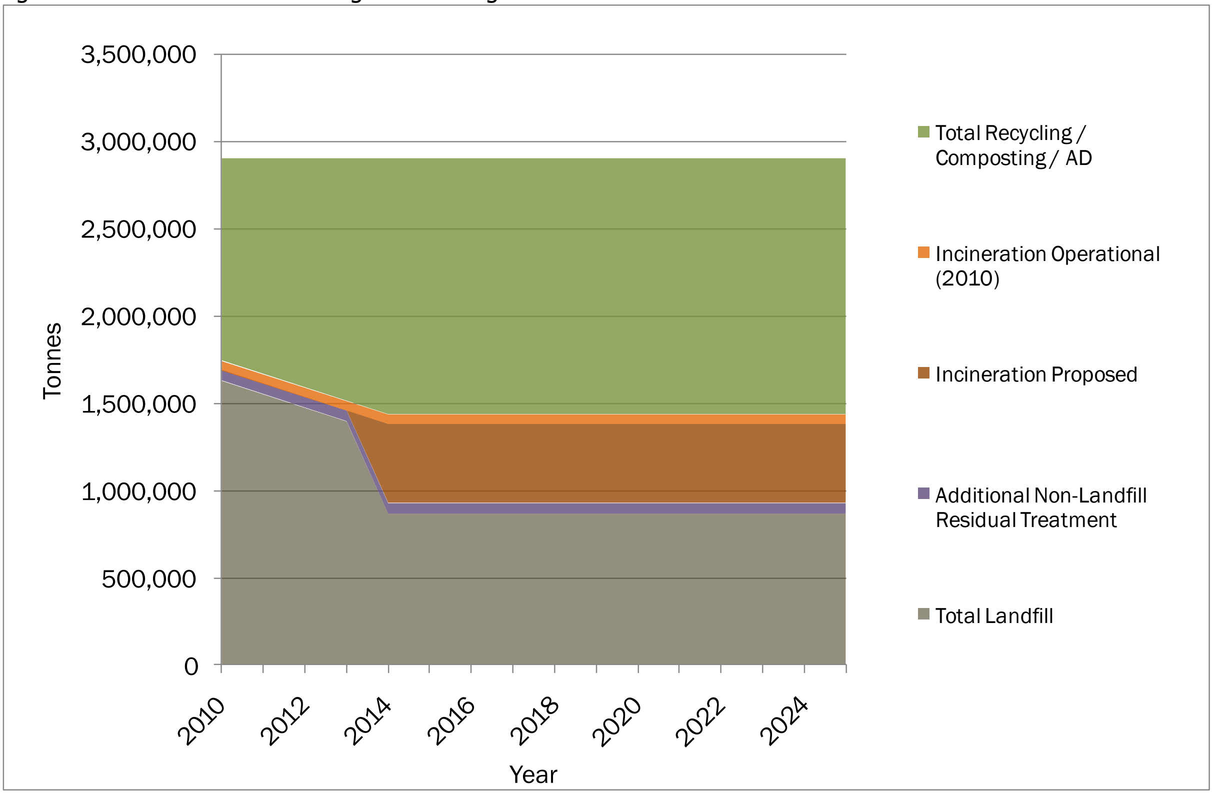


Figure 5: Household Waste Arisings and Management – Zero Waste Plan

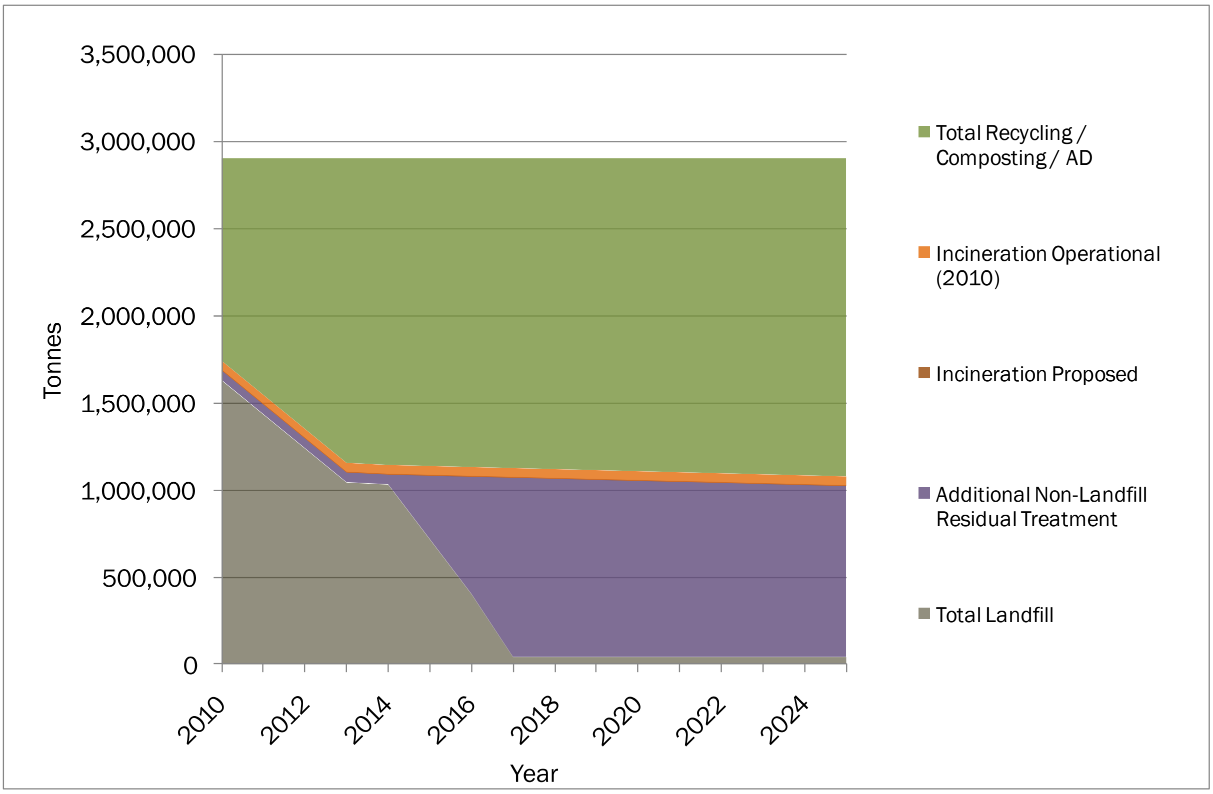


Table 15: Management of Household Waste under BaU and ZWP, 2010-2025

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BaU SCENARIO																
Total Arisings	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584
Total Recycling / Composting / AD	1,162,511	1,239,923	1,317,334	1,394,745	1,472,156	1,472,156	1,472,156	1,472,156	1,472,156	1,472,156	1,472,156	1,472,156	1,472,156	1,472,156	1,472,156	1,472,156
Incineration Operational (2010)	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179
Incineration Proposed	0	0	0	0	451,009	451,009	451,009	451,009	451,009	451,009	451,009	451,009	451,009	451,009	451,009	451,009
Additional Non-Landfill Treatment	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Landfill	1,627,894	1,550,483	1,473,071	1,395,660	867,240	867,240	867,240	867,240	867,240	867,240	867,240	867,240	867,240	867,240	867,240	867,240
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
ZWP SCENARIO																
Total Arisings	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584	2,905,584
Total Recycling / Composting / AD	1,162,511	1,357,710	1,552,908	1,748,106	1,760,083	1,766,053	1,772,022	1,777,992	1,783,962	1,789,932	1,795,902	1,801,872	1,807,842	1,813,812	1,819,781	1,825,751
Incineration Operational (2010)	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179	55,179
Incineration Proposed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Additional Non-Landfill Treatment	60,000	60,000	60,000	60,000	60,000	367,830	675,661	1,031,250	1,025,280	1,019,310	1,013,341	1,007,371	1,001,401	995,431	989,461	983,491
Landfill	1,627,894	1,432,696	1,237,497	1,042,299	1,030,323	716,522	402,722	41,163	41,163	41,163	41,163	41,163	41,163	41,163	41,163	41,163

Similar comments can be made regarding commercial waste. Figure 6 and Figure 7 show the pattern of commercial waste management under BaU and ZWP, respectively. The ZWP scenario shows higher rates of recycling / composting / AD, and higher rates of non-landfill residual waste treatment. This leads to lower rates of landfilling.

Figure 6: Commercial Waste Arisings and Management – Business as Usual

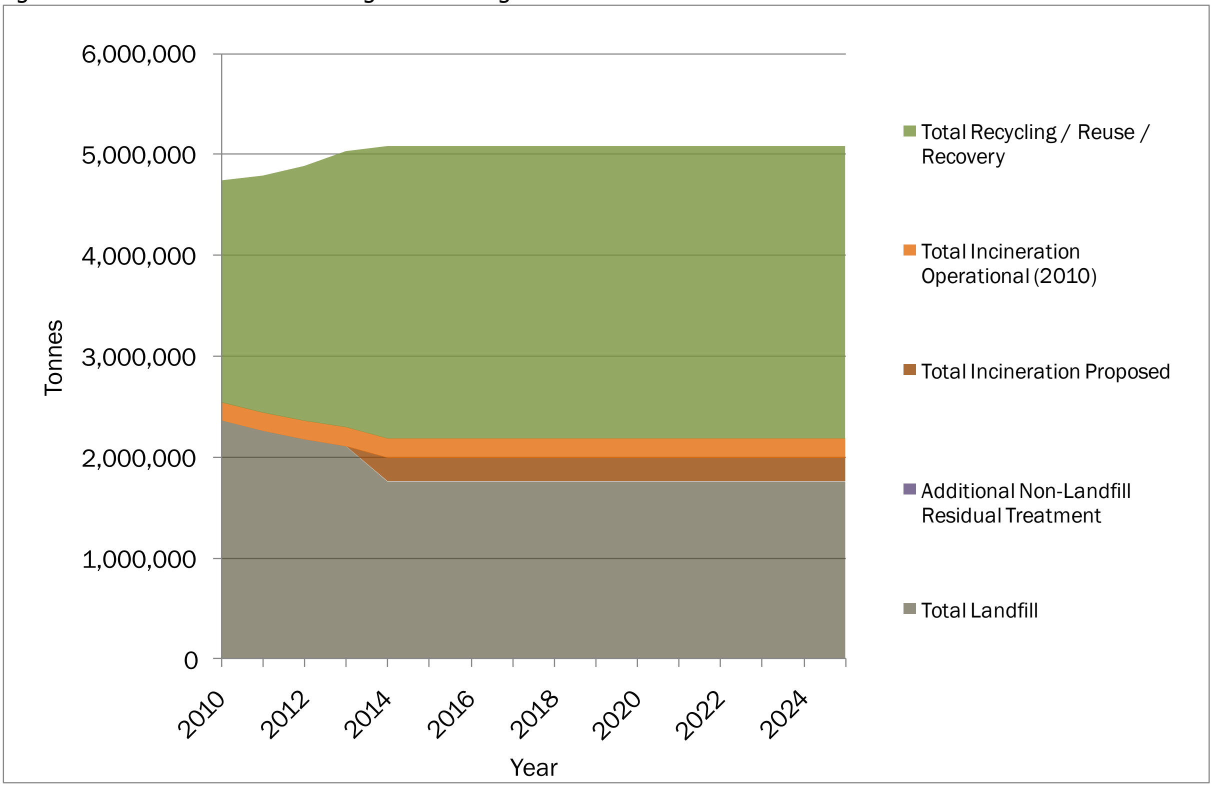


Figure 7: Commercial Waste Arisings and Management – Zero Waste Plan

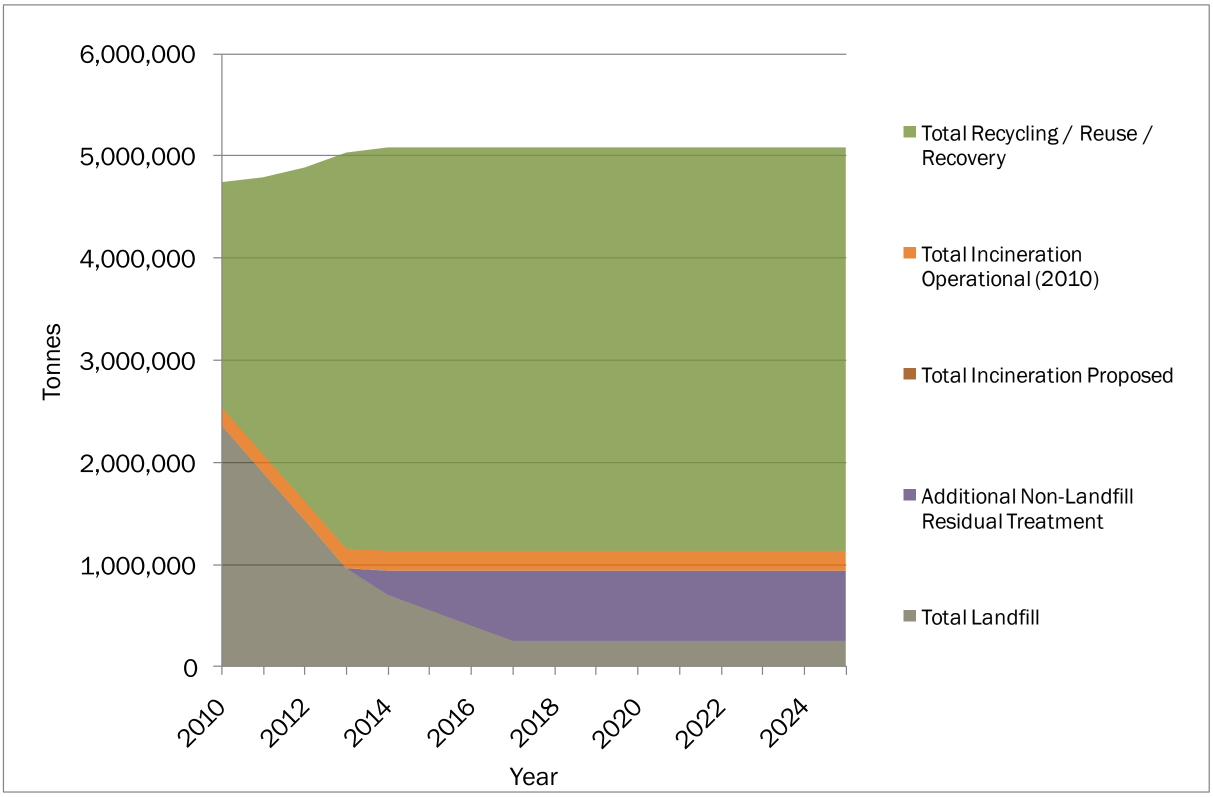


Figure 8 and Figure 9 show the pattern of industrial waste management under BaU and ZWP, respectively. Unlike the household and commercial sectors, the quantity of waste falls over time following an increase reflecting a 'bounce-back' in economic activity after the decline due to the recession. The ZWP scenario shows higher rates of recycling / composting / AD, and higher rates of non-landfill residual waste treatment. This leads to lower rates of landfilling. The raw data are presented for commercial and industrial waste combined in Table 16.

Figure 8: Industrial Waste Arisings and Management – Business as Usual

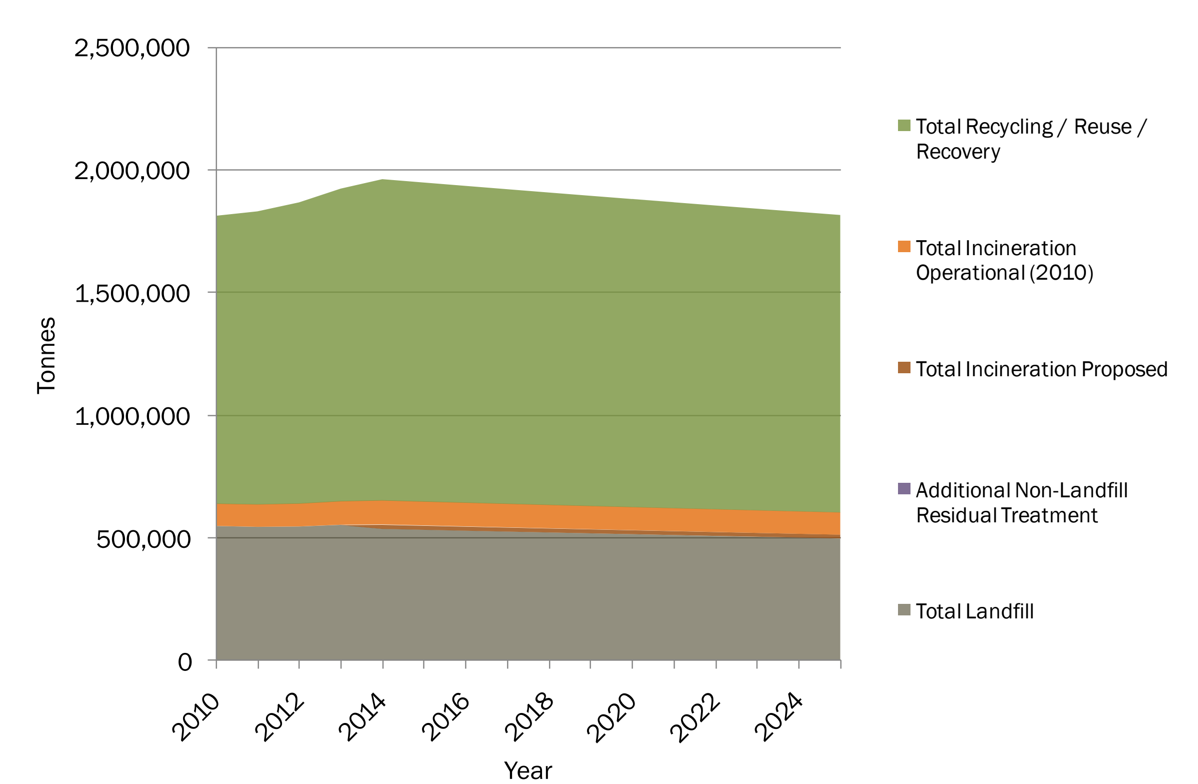


Figure 9: Industrial Waste Arisings and Management – Zero Waste Plan

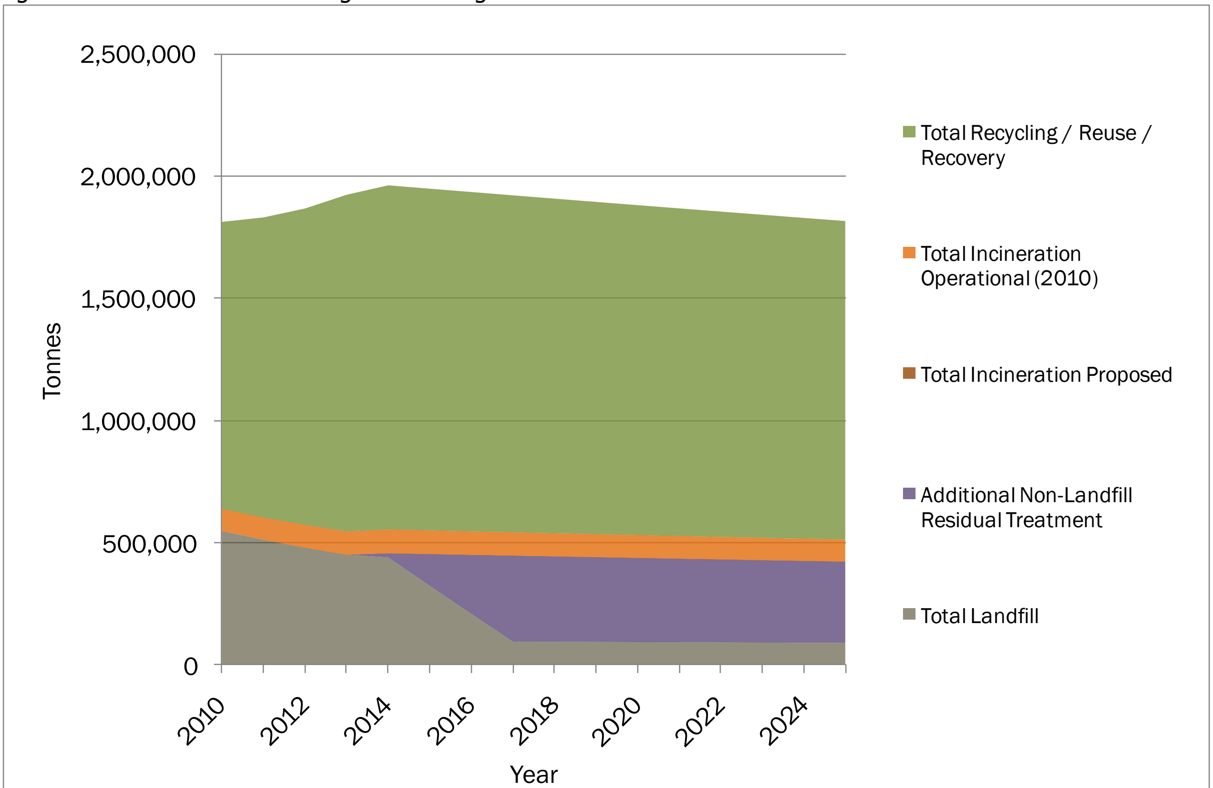


Table 16: Management of Commercial and Industrial Waste Under BaU and ZWP, 2010-2025

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
	BaU SCENARIO															
Arisings	6,562,374	6,627,998	6,760,558	6,963,375	7,052,269	7,038,517	7,024,861	7,011,301	6,997,835	6,984,464	6,971,187	6,958,002	6,944,910	6,931,909	6,918,999	6,906,180
Recycling / Reuse / Recovery	3,375,453	3,545,742	3,755,921	4,012,042	4,209,895	4,200,716	4,191,602	4,182,551	4,173,564	4,164,640	4,155,778	4,146,978	4,138,240	4,129,563	4,120,947	4,112,391
Non-Landfill Residual Treatment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Incineration Operational (2010)	272,253	274,976	280,475	288,889	292,735	292,052	291,373	290,700	290,030	289,366	288,706	288,051	287,400	286,754	286,113	285,476
Incineration Proposed	0	0	0	0	253,704	253,583	253,464	253,345	253,227	253,110	252,993	252,878	252,763	252,649	252,536	252,423
Landfill	2,914,668	2,807,281	2,724,161	2,662,443	2,295,935	2,292,165	2,288,422	2,284,705	2,281,014	2,277,349	2,273,709	2,270,095	2,266,506	2,262,942	2,259,404	2,255,890
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	
	ZWP SCENARIO															
Arisings	6,562,374	6,627,998	6,760,558	6,963,375	7,052,269	7,038,517	7,024,861	7,011,301	6,997,835	6,984,464	6,971,187	6,958,002	6,944,910	6,931,909	6,918,999	6,906,180
Recycling / Reuse / Recovery	3,375,453	3,940,952	4,562,150	5,257,665	5,360,732	5,350,873	5,341,084	5,331,363	5,321,710	5,312,125	5,302,606	5,293,155	5,283,769	5,274,450	5,265,195	5,256,005
Non-Landfill Residual Treatment	0	0	0	0	253,704	516,944	778,595	1,038,673	1,036,203	1,033,750	1,031,315	1,028,896	1,026,494	1,024,110	1,021,741	1,019,390
Incineration Operational (2010)	272,253	274,976	280,475	288,889	292,735	292,052	291,373	290,700	290,030	289,366	288,706	288,051	287,400	286,754	286,113	285,476
Incineration Proposed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landfill	2,914,668	2,412,070	1,917,933	1,416,820	1,145,098	878,647	613,809	350,565	349,892	349,223	348,559	347,900	347,245	346,595	345,950	345,309

Figure 10 and Figure 11 show the pattern of C&D waste management under BaU and ZWP, respectively. The ZWP scenario shows higher rates of recycling / composting / AD, and higher rates of non-landfill residual waste treatment. This leads to lower rates of landfilling. The raw data is presented for commercial and industrial waste combined in Table 17.

Figure 10: C&D Waste Arisings and Management – Business as Usual

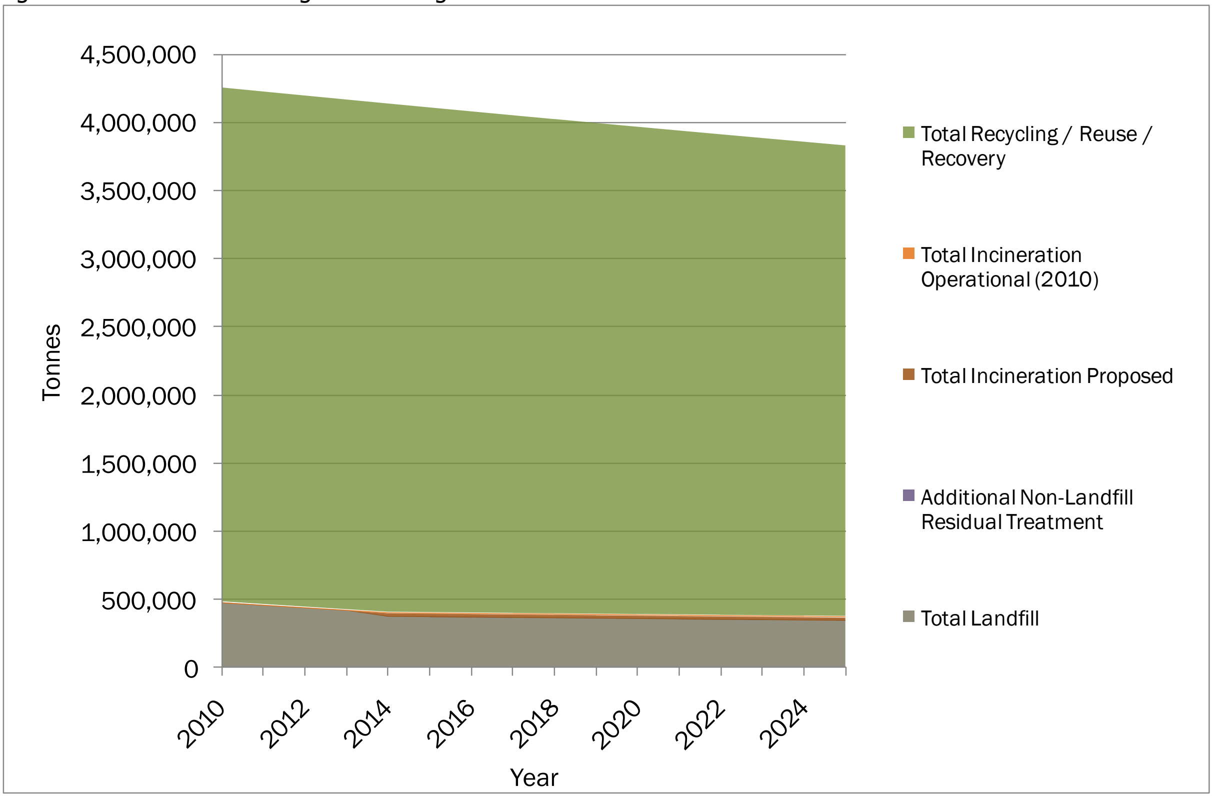


Figure 11: C&D Waste Arisings and Management – Zero Waste Plan

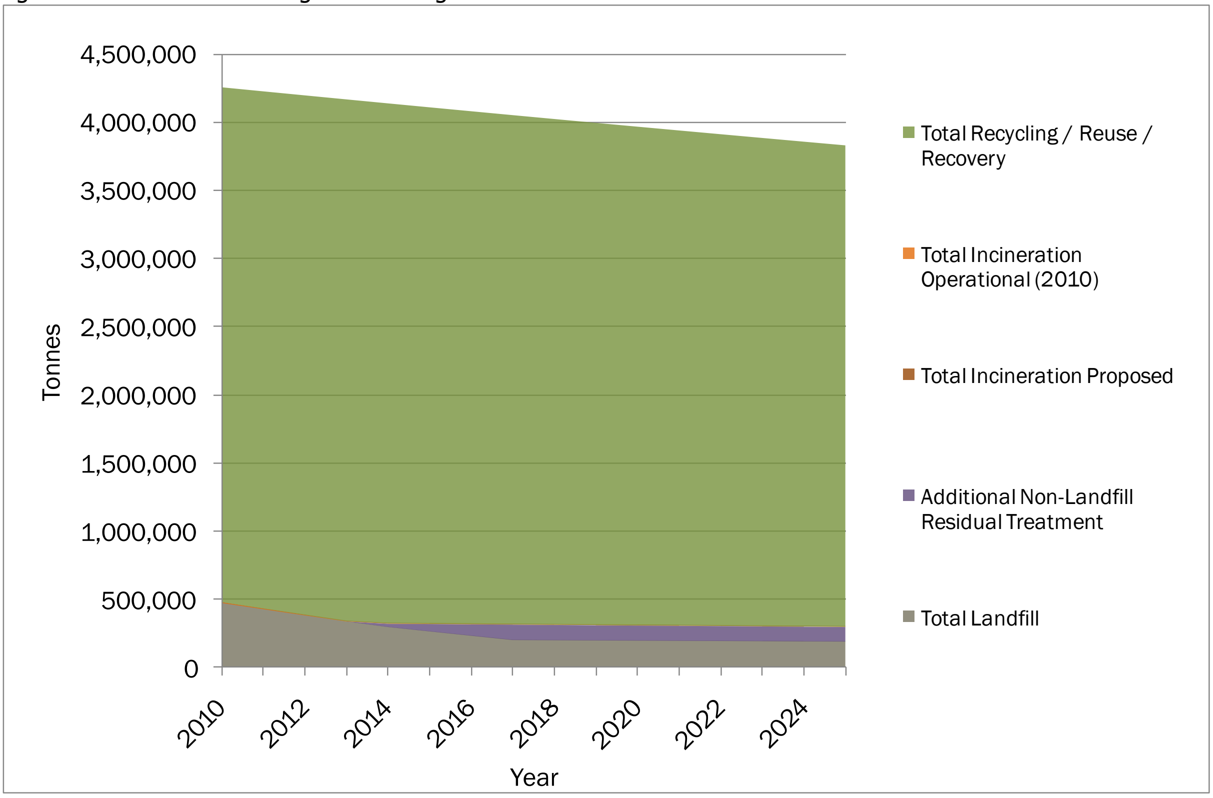


Table 17: Management of Construction and Demolition Waste under BaU and ZWP, 2010-2025

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
	BaU SCENARIO															
Arisings	4,256,388	4,226,594	4,197,008	4,167,629	4,138,455	4,109,486	4,080,720	4,052,155	4,023,789	3,995,623	3,967,654	3,939,880	3,912,301	3,884,915	3,857,720	3,830,716
Recycling / Reuse / Recovery	3,773,144	3,762,803	3,752,421	3,742,001	3,731,542	3,705,422	3,679,484	3,653,727	3,628,151	3,602,754	3,577,535	3,552,492	3,527,625	3,502,931	3,478,411	3,454,062
Additional Non-Landfill Treatment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Incineration Operational (2010)	7,207	7,156	7,106	7,056	7,007	6,958	6,909	6,861	6,813	6,765	6,718	6,671	6,624	6,578	6,532	6,486
Incineration Proposed	0	0	0	0	23,603	23,438	23,274	23,111	22,949	22,789	22,629	22,471	22,314	22,157	22,002	21,848
Landfill	476,038	456,635	437,480	418,571	376,302	373,668	371,052	368,455	365,876	363,315	360,772	358,246	355,738	353,248	350,776	348,320
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
	ZWP SCENARIO															
Arisings	4,256,388	4,226,594	4,197,008	4,167,629	4,138,455	4,109,486	4,080,720	4,052,155	4,023,789	3,995,623	3,967,654	3,939,880	3,912,301	3,884,915	3,857,720	3,830,716
Recycling / Reuse / Recovery	3,773,144	3,790,570	3,807,568	3,824,141	3,811,362	3,784,683	3,758,190	3,731,883	3,705,759	3,679,819	3,654,060	3,628,482	3,603,083	3,577,861	3,552,816	3,527,946
Additional Non-Landfill Treatment	0	0	0	0	23,603	53,082	82,148	110,803	110,028	109,257	108,493	107,733	106,979	106,230	105,487	104,748
Incineration Operational (2010)	7,207	7,156	7,106	7,056	7,007	6,958	6,909	6,861	6,813	6,765	6,718	6,671	6,624	6,578	6,532	6,486
Incineration Proposed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landfill	476,038	428,867	382,334	336,431	296,482	264,763	233,473	202,608	201,189	199,781	198,383	196,994	195,615	194,246	192,886	191,536

5.2. Recycling Rates

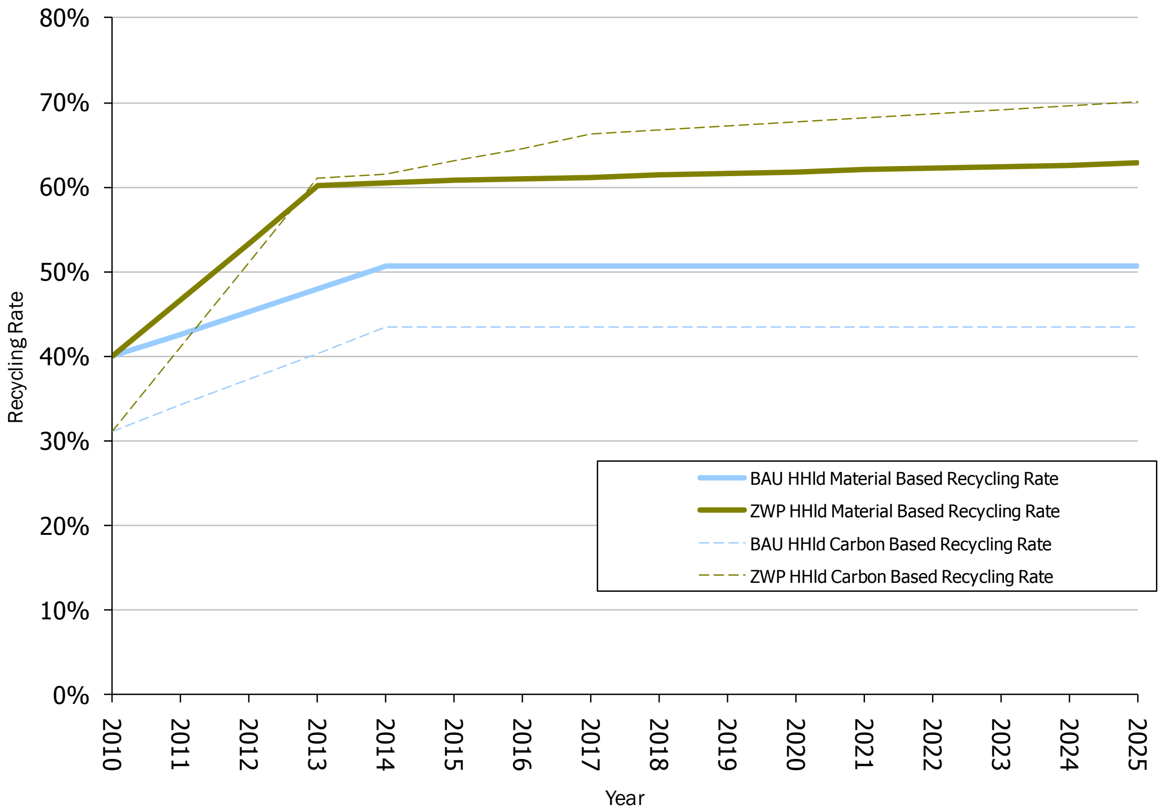
The household waste recycling rates, measured in terms of tonnage and the carbon metric, are shown alongside one another in Figure 12. Sections 4.4.1 and 4.4.2 explained the methodology used with regards to recycling rates for each waste stream for the BAU and ZWP scenarios respectively. The carbon metric recycling rates are calculated from material based recycling rates in line with the guidance provided by ZWS.[76]

The data shown here includes a contribution to the carbon metric recycling rate from recycling of metals associated with the management of residual waste (hence the uplift from 2017/18 under the ZWP Scenario). The 70% recycling rate is only just met in the period under examination. We believe that current composition and the current carbon metric makes this target difficult to meet. The rate has to more than double under the carbon metric, and achieving this demands a high capture of textiles and aluminium. Depending upon how textile composition is measured, this may not be straightforward.

C&I recycling rates are shown in Figure 13. The extent of the change between the Scenarios is not so great as for household waste. Baseline rates are somewhat higher, and carbon based rates are more easily exceeded. This reflects the lower proportion of 'low weighting' materials.

C&D recycling rates are shown in Figure 14. Here, carbon based targets are met even in the BaU Scenario. The extent of the change between the Scenarios is not so great as for household waste. Baseline rates are somewhat higher, and carbon based rates are more easily exceeded. This reflects the lower proportion of 'low weighting' materials.

Figure 12: Household Recycling Rates v Time



76 See Zero Waste Scotland (2011) The Scottish Carbon Metric, available at: http://www.wrap.org.uk/downloads/Technical_Report_FINAL.6fc98afe.10581.pdf

Figure 13: C&I Recycling Rates v Time

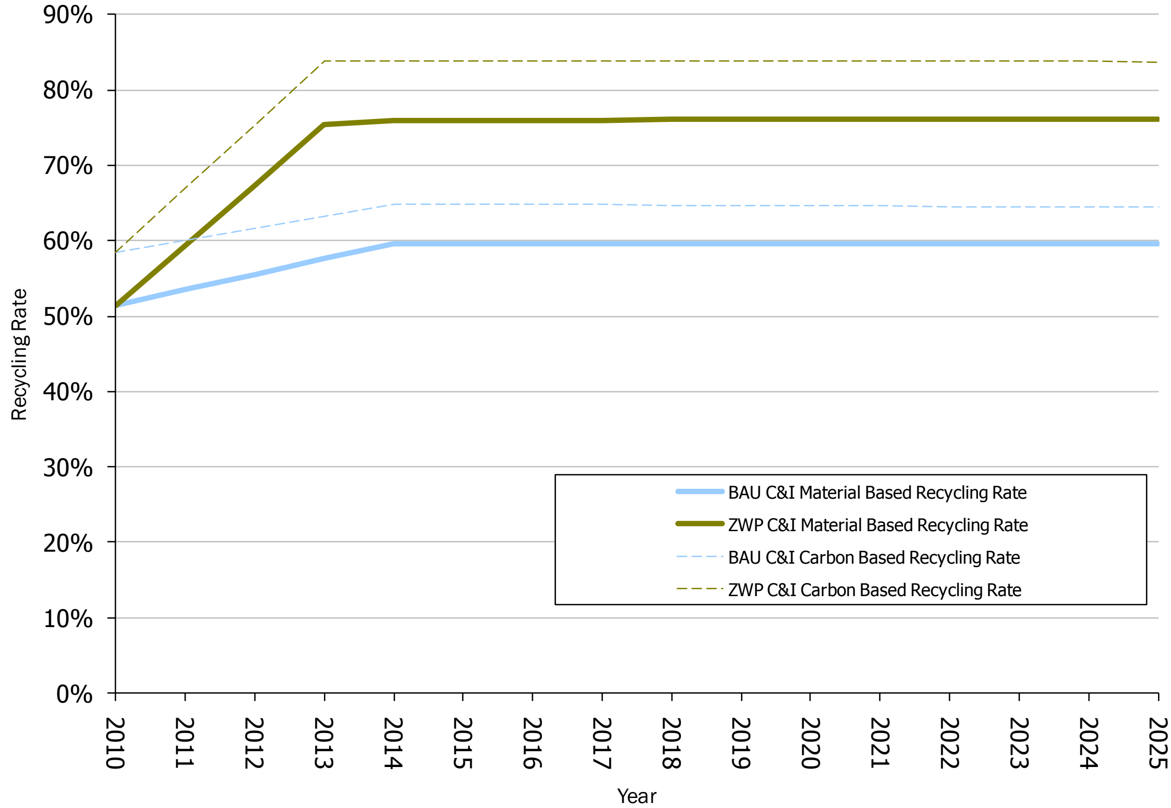
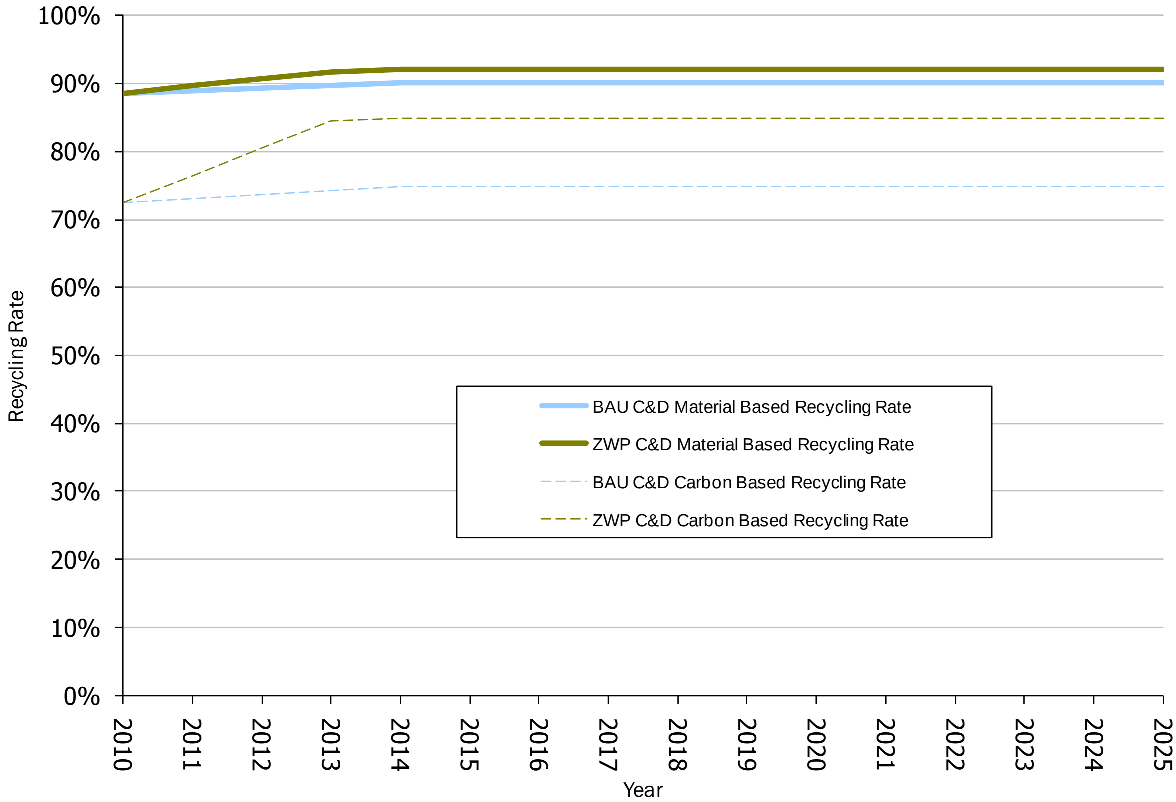


Figure 14: C&D Recycling Rates



Raw data on recycling rates for all streams is shown in Table 18.

Table 18: Material and Carbon Based Recycling Rates for Household, Commercial, Industrial and Construction and Demolition Wastes under BaU and ZWP

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
BAU HHld Material Based Recycling Rate	40%	43%	45%	48%	51%	51%	51%	51%	51%	51%	51%	51%	51%	51%	51%	51%
BAU HHld Carbon Based Recycling Rate	31%	34%	37%	40%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%
ZWP HHld Material Based Recycling Rate	40%	47%	53%	60%	61%	61%	61%	61%	61%	62%	62%	62%	62%	62%	63%	63%
ZWP HHld Carbon Based Recycling Rate	31%	41%	51%	61%	62%	63%	65%	66%	67%	67%	68%	68%	69%	69%	70%	70%
BAU Commercial Material Based Recycling Rate	46%	49%	52%	54%	57%	57%	57%	57%	57%	57%	57%	57%	57%	57%	57%	57%
BAU Commercial Carbon Based Recycling Rate	49%	51%	53%	55%	57%	57%	57%	57%	57%	57%	57%	57%	57%	57%	57%	57%
ZWP Commercial Material Based Recycling Rate	46%	57%	67%	77%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%
ZWP Commercial Carbon Based Recycling Rate	49%	60%	70%	81%	82%	82%	82%	83%	83%	83%	83%	83%	83%	83%	83%	83%
BAU Industrial Material Based Recycling Rate	65%	65%	66%	66%	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%
BAU Industrial Carbon Based Recycling Rate	84%	84%	84%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
ZWP Industrial Material Based Recycling Rate	65%	67%	69%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
ZWP Industrial Carbon Based Recycling Rate	84%	86%	89%	91%	91%	92%	92%	93%	93%	93%	93%	93%	93%	93%	93%	93%
BAU C&D Material Based Recycling Rate	89%	89%	89%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
BAU C&D Carbon Based Recycling Rate	72%	73%	74%	74%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
ZWP C&D Material Based Recycling Rate	89%	90%	91%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%
ZWP C&D Carbon Based Recycling Rate	72%	76%	81%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%

5.3. Financial Results for Individual sectors

5.3.1. Household Waste

For the year 2010, the model out-turns suggest a collection cost for household wastes of £147 million. This compares with a figure of £181 million from the Local Government Financial Statistics 2009-10 for the expenditure category 'Waste Collection'.[77] This includes some matters which are not included in our analysis (underlined below):

- Household waste collection (private dwellings and residential homes)
- Trade (i.e. commercial and industrial) waste
- Recycling (e.g. doorstep collections or bottle/paper banks for recycling, the costs of preparing, implementing and monitoring the authority's recycling plan)
- Waste strategy (include the costs of developing a waste strategy whether developed under the National Waste Strategy framework or determined locally. Waste strategy will normally encompass both waste collection and waste disposal so costs will need to be apportioned (see BVACOP for further information).

It should also be considered that our figures are based upon modelling of fairly well optimised collection systems. Some of the difference between the figures will reflect the differentials in efficiency between the modelled cost, and what local authorities are currently paying. Experience tells us that here is likely to be some slack in the current costs, and room for further efficiency gains.

The model out-turns suggest a cost for sorting, biologically treating and disposing of household wastes of £147 million. This compares with a figure of £213 million from the Local Government Financial Statistics 2009-10 category for 'Waste Disposal', which includes (as well as 'processing of recycled waste'): [78]

> *all the costs of waste disposal including landfill, incineration, centralised composting, salvage/recycling, trading of landfill allowances and closed landfill sites.*

Our modelled costs do not include matters associated with monitoring and managing closed landfill sites. Our costs are also related only to household wastes, and do not include the treatment and disposal of commercial waste collected by local authorities. It is difficult to understand, therefore, how close these figures really are in the absence of a more complete breakdown of costs reported under Local government Financial Statistics, and no such breakdown is, as we understand it, available.

Note that neither of the categories discussed above include litter and street cleaning which, according to guidance for completing Local Financial Returns, should be included under the heading 'Other Cleaning (not chargeable to roads)'.

Regarding the projections, for household waste, the total costs of collection, treatment, disposal etc., are as shown in Figure 15 and Figure 16 for the BAU and ZWP scenarios, respectively. These two scenarios are then shown relative to one another in Figure 17. The raw data are shown in Table 19. The Figures shown are for annualised costs, expressed in real 2010 sterling values. All recycled material, including that collected commingled, is shown to generate revenues as shown by the green bars. The sorting costs (MRF fees) shown are therefore the gross sorting costs, not those which are net of material revenues. Both Figures are shown on the same scale. The net costs are shown as the line drawn across the Figures.

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[77] *The Scottish Government (2011) Scottish Local Government Financial Statistics, February 2011, Annex F. downloadable from http://www.scotland.gov.uk/Topics/Statistics/Browse/Local-Government-Finance/PubScottishLGFStats/Q/EditMode/on/ForceUpdate/on*

[78] *The Scottish Government (2011) Scottish Local Government Financial Statistics, February 2011, Annex F. downloadable from http://www.scotland.gov.uk/Topics/Statistics/Browse/Local-Government-Finance/PubScottishLGFStats/Q/EditMode/on/ForceUpdate/on*

Figure 15: Household Waste Total Costs – BAU (real 2010 £)

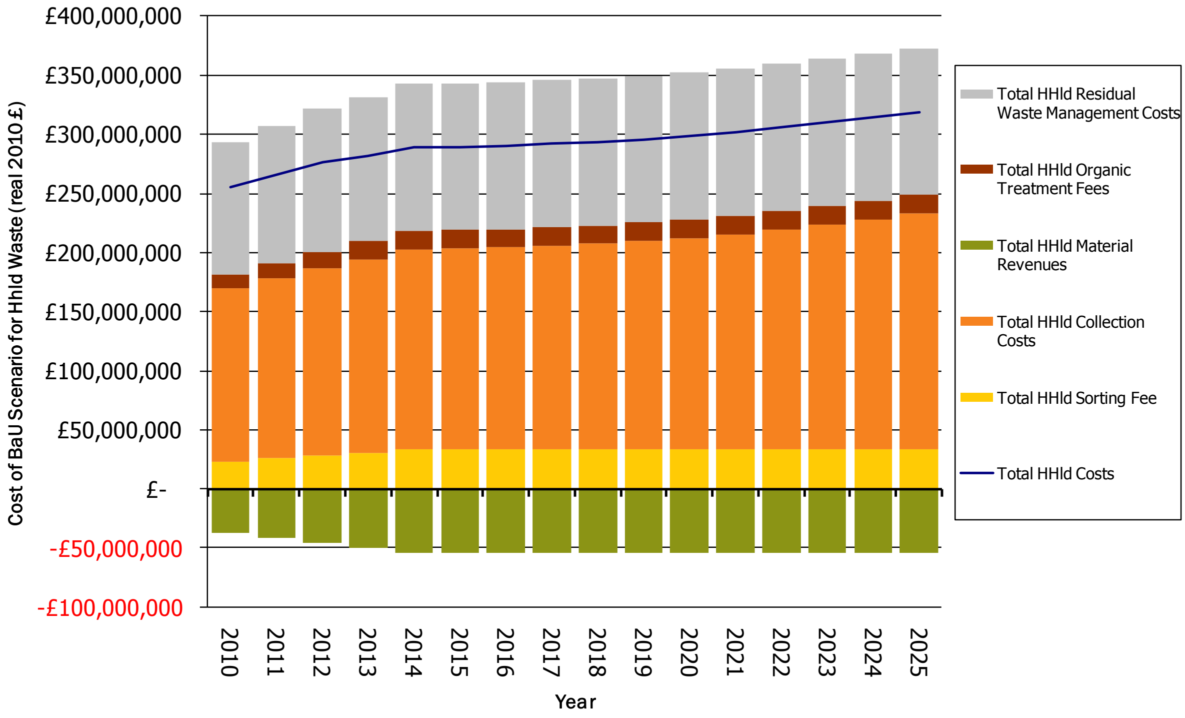
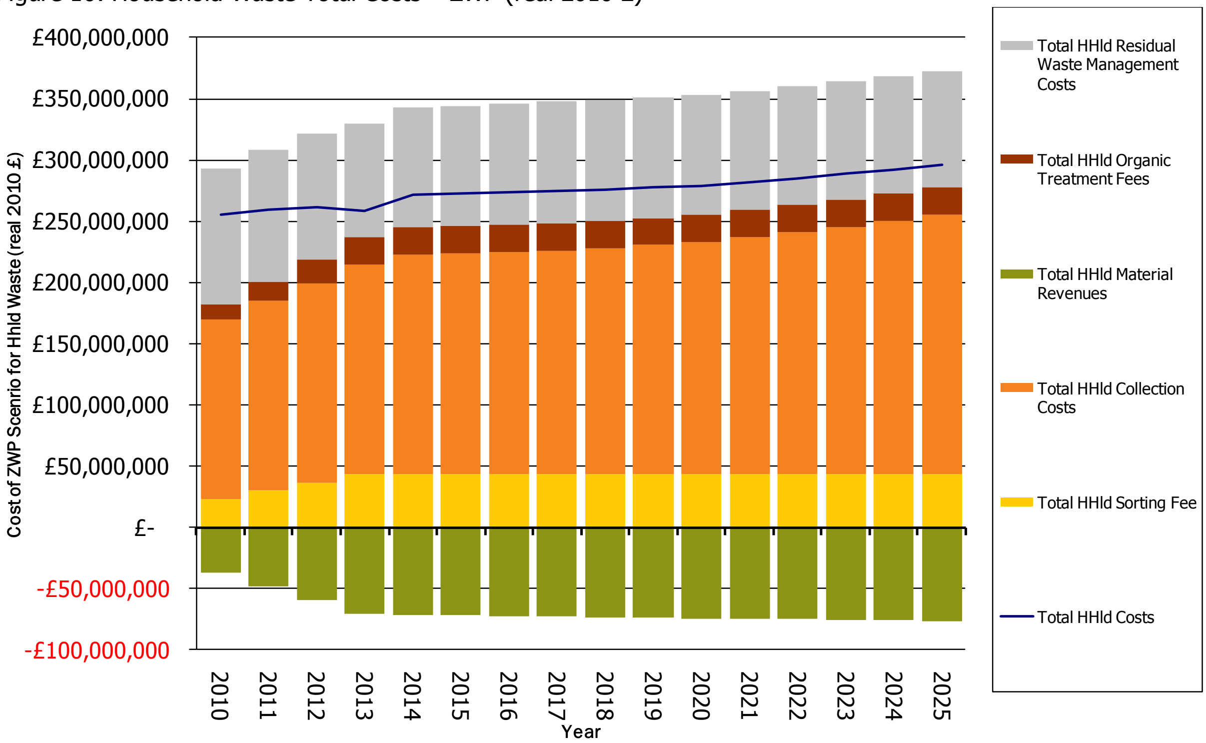


Figure 16: Household Waste Total Costs – ZWP (real 2010 £)



It will be noted that the line slopes upwards slightly in both cases. This is a reflection of growing household numbers and the effect this has on kerbside collection costs.[79] The other key point is that under ZWP, the total figure reached in 2025 is lower than in BaU. This is because the combined effects of:

[79] *Projections for household numbers have been estimated from population projections taken from National Statistics (2009) Projected Population of Scotland (2008-based), Report for General Register Office for Scotland, 21 October 2009, http://www.gro-scotland.gov.uk/statistics/theme/population/projections/scotland/2008-based/index.html. We have assumed household sizes remain constant over this period, and have simply increased the household numbers in each local authority at*

1. Higher household collection costs;
2. Higher sorting costs; and
3. Higher organic treatment costs

are more than offset by:

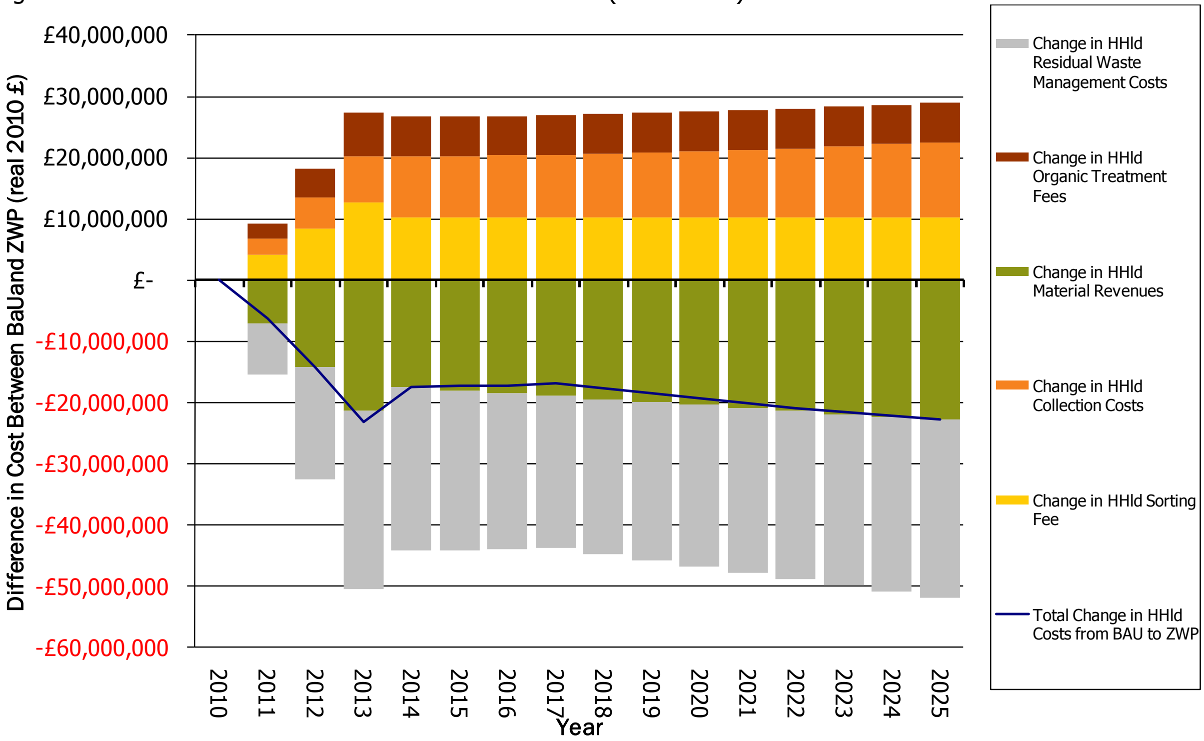
1. The increase in material revenues; and
2. The reduction in the costs of residual waste treatment.

These differences are shown more clearly in Figure 17 and Table 19, each of which shows the changes in costs of ZWP relative to BaU in any given year.

The pattern indicates that in early years, the effect of the requirement to sort dry recyclables and food reduces costs to the authorities. This is because under BaU, local authorities are assumed not to be recycling and composting at a level which would appear to be justified by the prevailing 'avoided cost of disposal' (represented, in most local authorities, by the avoided costs of collecting and landfilling refuse).

In the year 2014, the costs increase as the effect of the requirement to sort waste is assumed to have been felt in full, but landfill tax is still rising. In the years from 2014 to 2017, however, the difference in costs remains broadly constant as residual waste management is switched away from landfill into treatments with the same cost. There is a marginal upturn in cost reflecting the assumed increase in household numbers in this period, and the effect this has on household waste collection costs.

Figure 17: Household Waste Costs – ZWP relative to BAU (real 2010 £)



the rate of increase of population. The increase equates to a compound growth rate in household numbers of around 0.34% per annum in the period 2008-2023.

Table 19: Costs for Management of Household Waste under BaU and ZWP (real 2010 £, millions)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BaU SCENARIO																
Total HHld Collection Costs	£147	£152	£158	£164	£170	£170	£171	£173	£174	£177	£179	£183	£186	£191	£195	£200
Total HHld Material Revenues	-£37	-£42	-£46	-£50	-£54	-£54	-£54	-£54	-£54	-£54	-£54	-£54	-£54	-£54	-£54	-£54
Total HHld Organic Treatment Fees	£12	£13	£14	£15	£16	£16	£16	£16	£16	£16	£16	£16	£16	£16	£16	£16
Total HHld Residual Waste Management Costs	£111	£116	£121	£122	£124	£124	£124	£124	£124	£124	£124	£124	£124	£124	£124	£124
Total HHld Sorting Fee	£23	£26	£28	£31	£33	£33	£33	£33	£33	£33	£33	£33	£33	£33	£33	£33
Total HHld Costs	£256	£266	£276	£282	£289	£290	£290	£292	£294	£296	£299	£302	£306	£310	£314	£319
ZWP SCENARIO																
Total HHld Collection Costs	£147	£155	£163	£171	£180	£180	£181	£183	£185	£187	£190	£194	£198	£202	£207	£212
Total HHld Material Revenues	-£37	-£49	-£60	-£71	-£71	-£72	-£72	-£73	-£73	-£74	-£74	-£75	-£75	-£76	-£76	-£77
Total HHld Organic Treatment Fees	£12	£15	£19	£22	£22	£22	£22	£22	£22	£22	£22	£22	£22	£22	£22	£22
Total HHld Residual Waste Management Costs	£111	£108	£103	£93	£98	£98	£99	£100	£99	£99	£98	£98	£97	£96	£96	£95
Total HHld Sorting Fee	£23	£30	£37	£43	£43	£43	£43	£43	£43	£43	£43	£43	£43	£43	£43	£43
Total HHld Costs	£256	£260	£262	£259	£272	£272	£273	£275	£276	£277	£279	£282	£285	£288	£292	£296
Additional Cost of ZWP	£0	-£6	-£14	-£23	-£17	-£17	-£17	-£17	-£18	-£19	-£19	-£20	-£21	-£22	-£22	-£23

Once all residual waste treatment is in place (by 2017 in the central scenario), the costs of ZWP start to fall as the model assumes that there is sustained improvement over time in recycling at HWRCs. This improvement in recycling is less expensive than residual waste treatment.

In our modelling of this Central Case, it is assumed that the alternative treatments for residual waste cost the same as landfill. The implications of this being untrue are considered in Section 6.2 and examined in Section 6.2 7.3.

5.3.2. C&I Waste

Total waste management costs have not been calculated for the waste streams other than household waste. As such, the results are presented as the change in costs for each Scenario relative to the situation in 2010 (see Figure 18 and Figure 19) and as the change in costs moving from BaU to ZWP (see Figure 20). The raw data are shown in Table 20.

As with the household waste stream, under ZWP, there is a more substantial outlay on collection, sorting and biological treatment, but an increase in revenue from material sales, and a reduced outlay on disposal. In the period before all waste needs to be treated, this leads to barely any difference in cost as compared with BaU (see Figure 20). The picture is, however, more finely balanced than with the household waste stream. The avoided costs of residual waste management only just compensate for the additional costs of the new collection schemes. This is partly to do with the fact that the model assumes a reasonably rational response to the landfill tax under BaU, so that additional recycling tends not to save so much money as under the household situation.

In 2013, what were marginal savings become small increases in costs. This is because the impetus to recycle is weakened as the effects of the requirement to sort have run their course. Yet, in 2013 and 2014, landfill tax is still rising. The costs of switching to residual waste treatments and away from landfill remains positive until the tax reaches its highest level. This imposes additional costs on the ZWP Scenario. For C&I waste, therefore, this situation is maintained once landfill tax stops rising in real terms.

Figure 18: C&I Waste Costs - BAU relative to 2010 (real 2010 £)

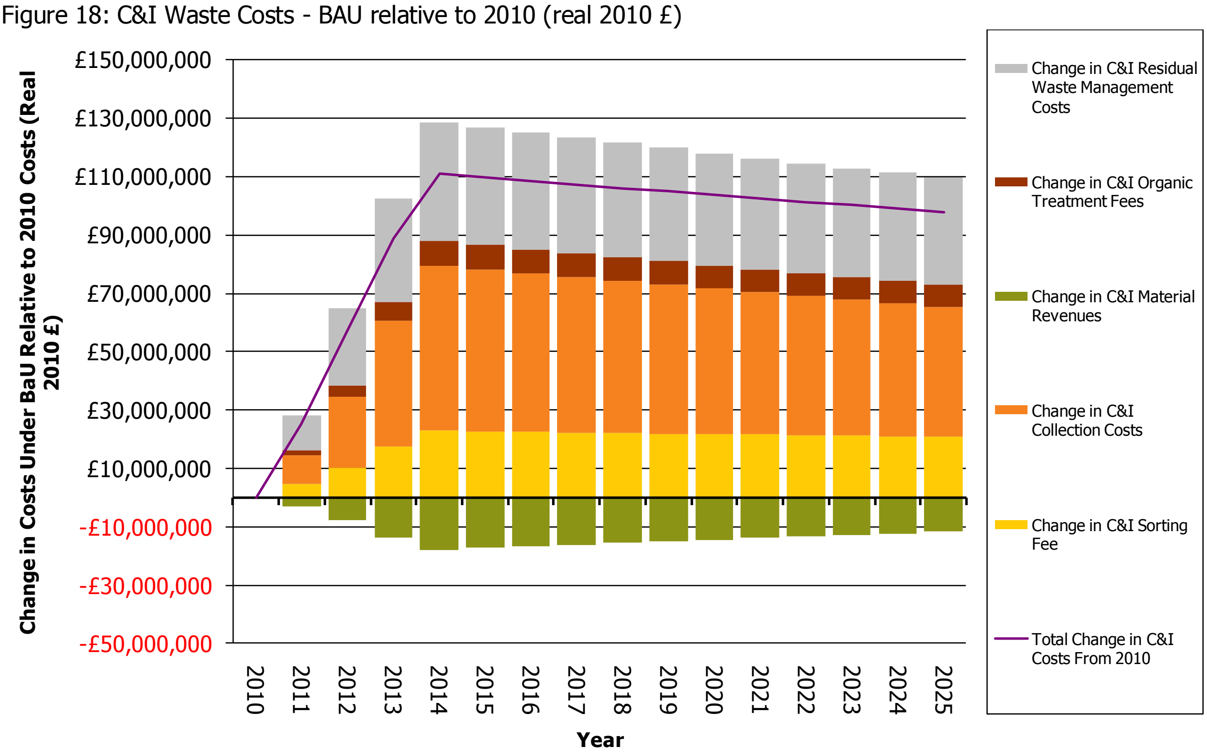


Figure 19: C&I Waste Costs - ZWP relative to 2010 (real 2010 £)

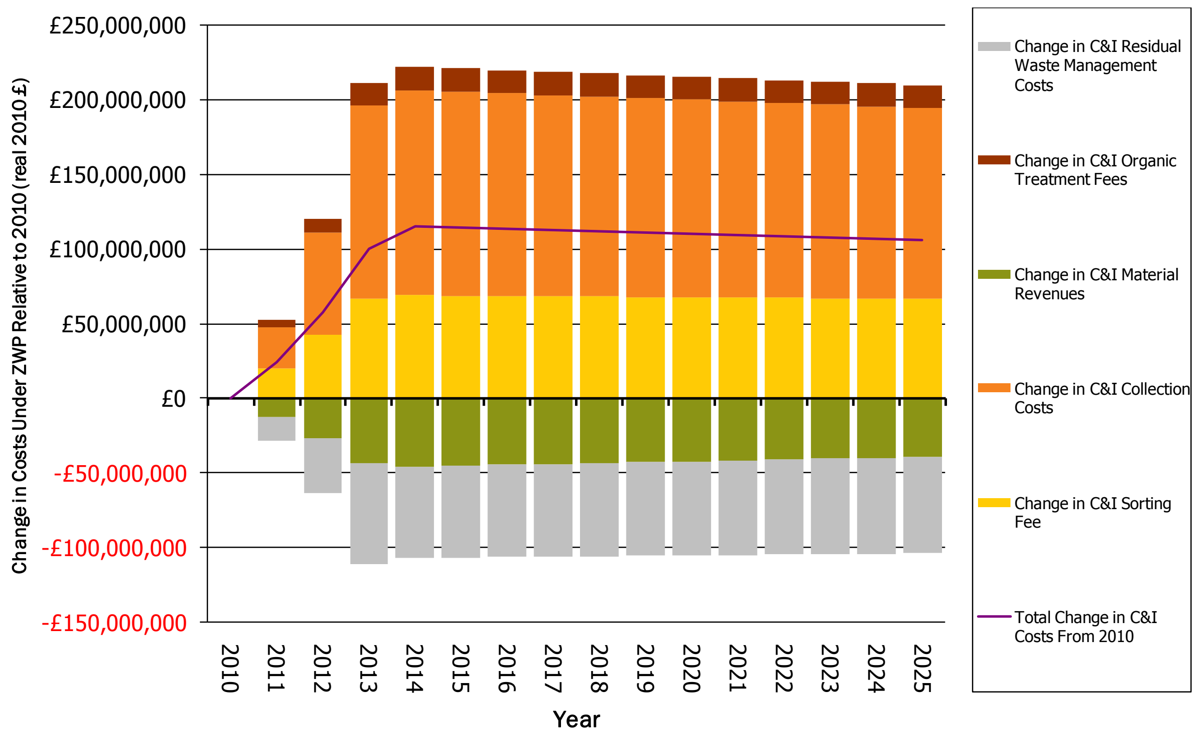


Figure 20: C&I Waste Costs - ZWP relative to BAU (real 2010 £)

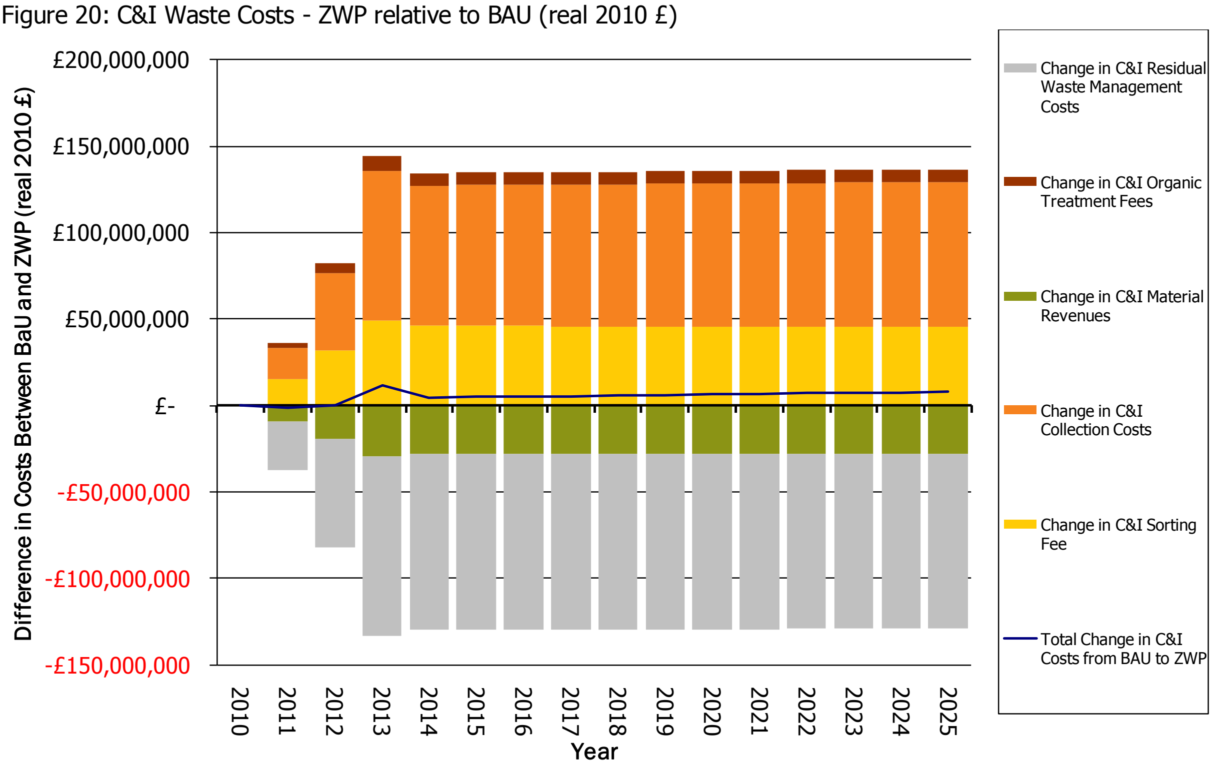


Table 20: Costs for Management of Commercial and Industrial Waste under BaU and ZWP (real 2010 £, millions)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BaU SCENARIO																
Change in C&I Collection Costs	£0	£10	£24	£43	£57	£55	£54	£53	£52	£51	£50	£49	£48	£47	£46	£45
Change in C&I Material Revenues	£0	-£3	-£8	-£14	-£18	-£17	-£17	-£16	-£16	-£15	-£14	-£14	-£13	-£13	-£12	-£12
Change in C&I Organic Treatment Fees	£0	£2	£4	£6	£9	£8	£8	£8	£8	£8	£8	£8	£8	£8	£8	£8
Change in C&I Residual Waste Management Costs	£0	£12	£26	£36	£41	£40	£40	£40	£39	£39	£38	£38	£38	£37	£37	£37
Change in C&I Sorting Fee	£0	£5	£10	£18	£23	£23	£23	£22	£22	£22	£22	£22	£21	£21	£21	£21
Total Change in C&I Costs From 2010	£0	£25	£57	£89	£111	£110	£109	£107	£106	£105	£104	£103	£101	£100	£99	£98
ZWP SCENARIO																
Change in C&I Collection Costs	£0	£28	£69	£130	£138	£137	£136	£135	£134	£133	£132	£132	£131	£130	£129	£128
Change in C&I Material Revenues	£0	-£13	-£27	-£43	-£46	-£45	-£45	-£44	-£43	-£43	-£42	-£42	-£41	-£40	-£40	-£39
Change in C&I Organic Treatment Fees	£0	£5	£10	£15	£16	£16	£16	£16	£16	£15	£15	£15	£15	£15	£15	£15
Change in C&I Residual Waste Management Costs	£0	-£16	-£36	-£68	-£61	-£61	-£62	-£62	-£62	-£63	-£63	-£63	-£64	-£64	-£64	-£65
Change in C&I Sorting Fee	£0	£20	£42	£67	£69	£69	£69	£68	£68	£68	£68	£68	£67	£67	£67	£67
Total Change in C&I Costs From 2010	£0	£24	£57	£101	£116	£115	£114	£113	£112	£111	£110	£109	£109	£108	£107	£106
Additional Cost of ZWP	£0	-£1	£0	£12	£5	£5	£5	£6	£6	£6	£7	£7	£7	£7	£8	£8

5.3.3. C&D Waste

The effect of moving from the BaU to the ZWP Scenario on the costs of C&D waste management is shown in Figure 21, with the raw data shown in Table 21. The Figure and Table show that there are reductions in cost in early years reflecting the potential for additional recycling at costs below the cost of landfilling. Our modelling suggests that the costs of waste collection under the ZWP will increase relative to BaU. However, these costs are more than offset by savings on residual waste management.

In the case of the C&D sector, we have assumed that some material being landfilled at the lower rate of tax is required to be treated. Hence, in the years from 2014-2017, there is a steady drop in the extent of the savings generated by the ZWP as some residual waste switches from inert landfills (where the disposal cost is much lower) to higher cost treatments. Even so, net savings result from the ZWP, albeit these are relatively small owing to the fact that a very large proportion of material is already recycled under the BaU Scenario.

Figure 21: C&D Waste Costs - ZWP relative to BAU (real 2010 £)

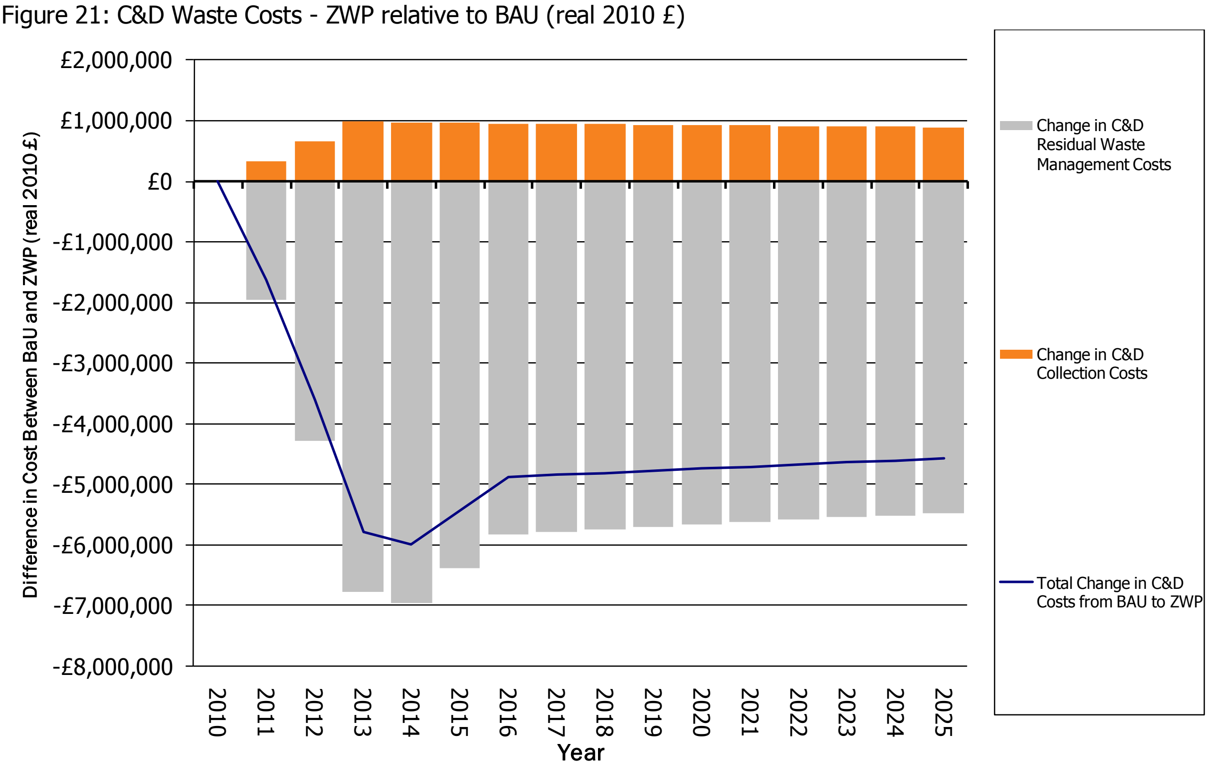


Table 21: Difference in Costs between BaU and ZWP for Construction and Demolition Wastes (real 2010 £, millions)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Change in C&D Collection Costs	£0.00	£0.34	£0.67	£1.00	£0.97	£0.96	£0.95	£0.95	£0.94	£0.93	£0.93	£0.92	£0.91	£0.91	£0.90	£0.90
Change in C&D Residual Waste Management Costs	£0.00	-£1.96	-£4.28	-£6.78	-£6.96	-£6.39	-£5.84	-£5.80	-£5.75	-£5.71	-£5.67	-£5.63	-£5.59	-£5.55	-£5.51	-£5.47
Total Change in C&D Costs From 2010	£0.00	-£1.62	-£3.61	-£5.79	-£5.99	-£5.43	-£4.88	-£4.85	-£4.81	-£4.78	-£4.74	-£4.71	-£4.68	-£4.64	-£4.61	-£4.58

5.4. Cost of Regulations

Table 23 summarises the administrative costs of implementing the ZWP Regulations which were used in the model. These costs are based upon estimates of the time involved for businesses and regulators to implement and enforce the relevant regulations and are derived from a number of assumptions. These estimated costs would be shared across the various different actors both affected by and implementing the Regulations, for example, Scottish Government, businesses, the waste management industry, SEPA and local authorities.

Table 223: Administrative Costs of ZWP Regulations (real 2010 £, '000s)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	TOTAL (NPV)
TOTAL	£0	-£2,327	-£1,002	-£953	-£941	-£1,007	-£931	-£931	-£931	-£941	-£941	-£941	-£941	-£941	-£941	-£11,716

5.5. Net Results: Relative Impacts of the ZWP Scenario to Business as Usual

The costs of the ZWP scenario relative to BaU, including regulatory costs, are shown in Figure 22. This shows a net saving associated with the Scenario. The pattern is broadly as follows:

- Additional costs are incurred in collection, sorting, treatment of organics and the implementation of the Regulations;
- Savings are made in respect of residual waste treatment costs owing to this additional recycling / composting / digestion, and revenues are generated from material sales; and
- As residual waste switches from landfill to other residual waste treatments, there is effectively no impact on costs as the costs of the alternatives are assumed to be the same as the costs of landfilling.

Given the number of assumptions used in the model, the results from this Central Case should be considered in the light of the assumptions made. Sensitivity analysis is considered in Section 7.

The situation is represented differently in Figure 23, which highlights the additional costs by waste stream. This shows how the bulk of the savings are related to the household waste stream. Indeed, the key item driving the savings from the ZWP is the additional recycling and the avoided costs of residual waste management related to this. The C&D and C&I waste streams make more measured contributions.

These figures are relatively uncertain, given both the quality of the data and the range of assumptions made. There are reasons to believe that these costs could change under alternative assumptions, some of which are tested in sensitivity analysis below.

The raw data underpinning the Figures can be found in Table 23 and Table 24.

Figure 22: All Waste Streams Costs - ZWP relative to BAU (real 2010 £)

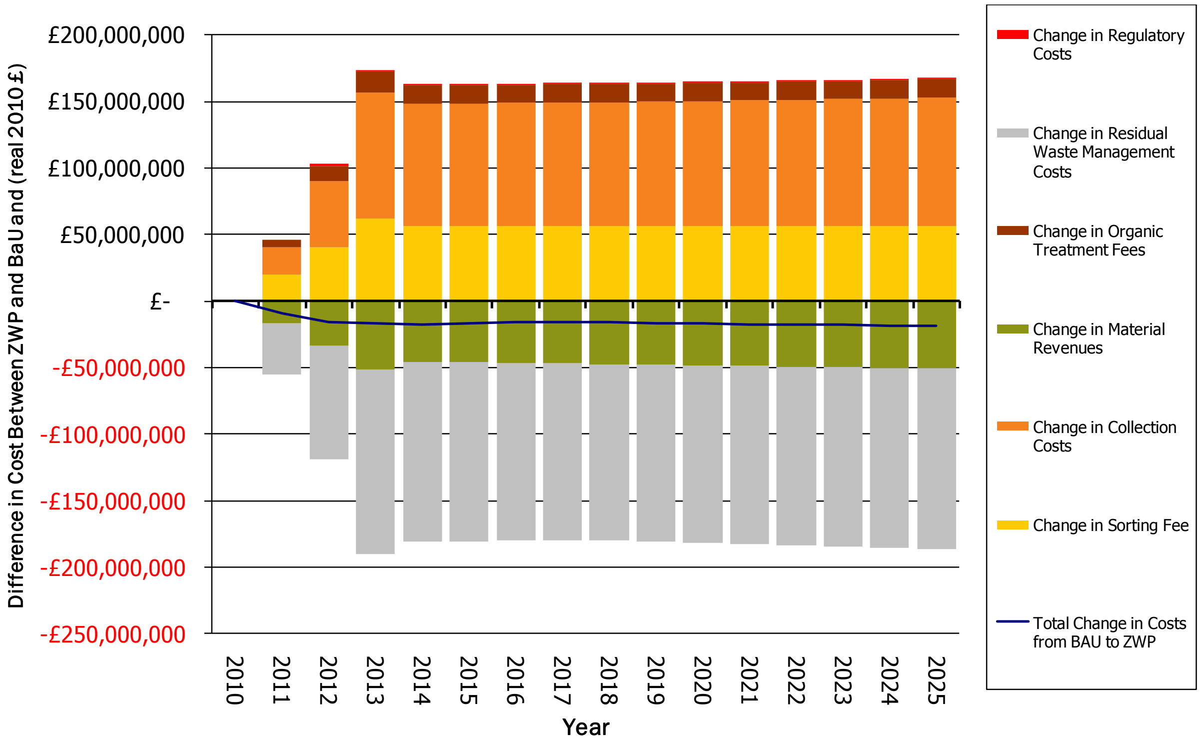


Figure 23: Costs of ZWP relative to BAU by Waste Stream (real 2010 £, millions)

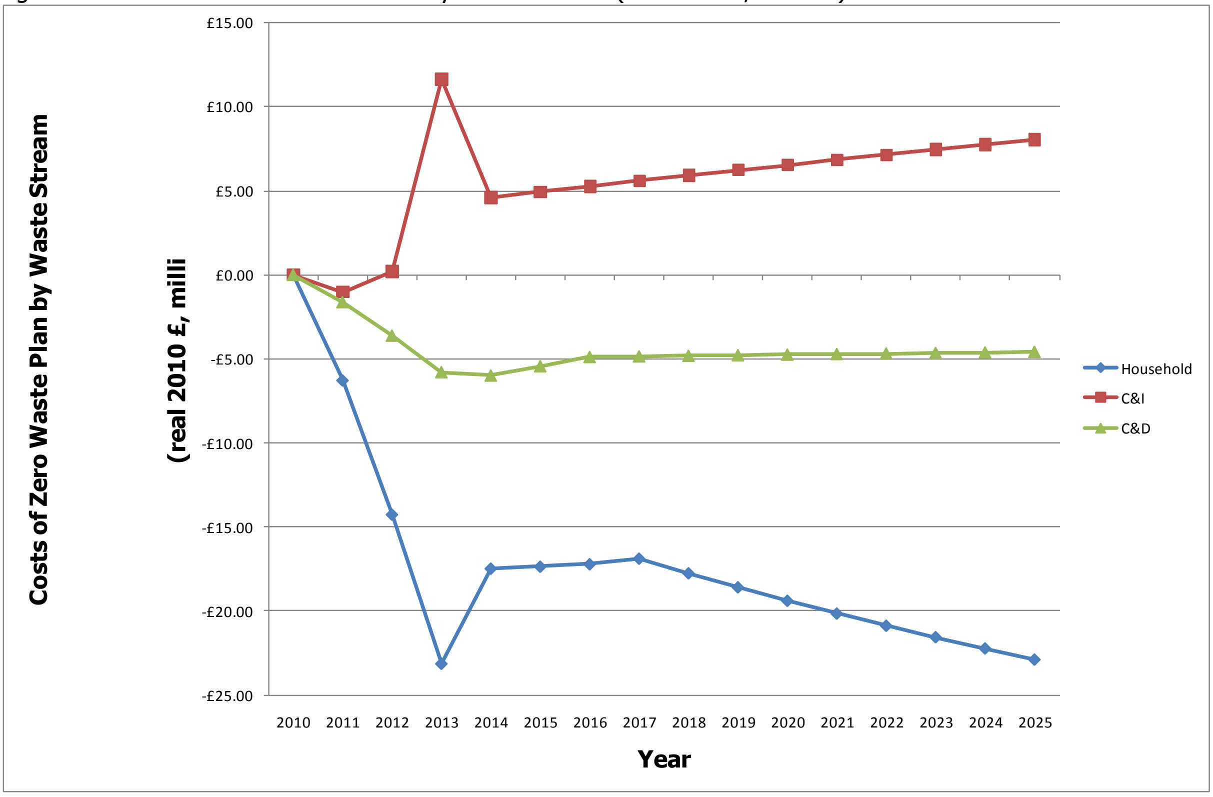


Table 23: All Waste Streams Costs - ZWP relative to BAU (real 2010 £ millions)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Change in Collection Costs	£0.00	£20.76	£50.32	£95.01	£92.17	£92.43	£92.72	£93.04	£93.38	£93.76	£94.17	£94.62	£95.10	£95.61	£96.14	£96.67
Change in Material Revenues	£0.00	-£16.52	-£33.42	-£50.99	-£45.60	-£46.04	-£46.49	-£46.93	-£47.38	-£47.82	-£48.27	-£48.72	-£49.16	-£49.61	-£50.05	-£50.50
Change in Organic Treatment Fees	£0.00	£5.15	£10.43	£15.92	£13.60	£13.64	£13.67	£13.71	£13.74	£13.78	£13.81	£13.84	£13.88	£13.91	£13.94	£13.98
Change in Residual Waste Management Costs	£0.00	-£38.18	-£85.37	-£139.20	-£135.48	-£134.29	-£133.11	-£132.30	-£132.72	-£133.14	-£133.57	-£133.99	-£134.41	-£134.84	-£135.26	-£135.69
Change in Sorting Fee	£0.00	£19.87	£40.37	£62.00	£56.45	£56.42	£56.40	£56.37	£56.34	£56.31	£56.28	£56.25	£56.22	£56.20	£56.17	£56.14
Change in Regulatory Costs	£0.00	£0.00	£2.33	£1.00	£0.95	£0.94	£1.01	£0.94	£0.94	£0.94	£0.94	£0.94	£0.94	£0.94	£0.94	£0.94
Total Change in Costs from BAU to ZWP	£0.00	-£8.92	-£15.33	-£16.26	-£17.90	-£16.90	-£15.81	-£15.18	-£15.69	-£16.18	-£16.63	-£17.05	-£17.44	-£17.78	-£18.13	-£18.47

Table 24: Costs of ZWP relative to BAU by Waste Stream (real 2010 £, millions)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Household	£0.00	-£6.28	-£14.26	-£23.12	-£17.47	-£17.35	-£17.21	-£16.88	-£17.75	-£18.58	-£19.38	-£20.14	-£20.86	-£21.54	-£22.21	-£22.87
C&I	£0.00	-£1.01	£0.21	£11.65	£4.61	£4.94	£5.27	£5.60	£5.92	£6.24	£6.55	£6.86	£7.16	£7.46	£7.75	£8.04
C&D	£0.00	-£1.62	-£3.61	-£5.79	-£5.99	-£5.43	-£4.88	-£4.85	-£4.81	-£4.78	-£4.74	-£4.71	-£4.68	-£4.64	-£4.61	-£4.58

5.6. Capital Costs of Facilities under the Scenarios

The capital costs for the facilities which we expect to be required under the two Scenarios are shown in the Figures that follow. It should be noted that these capital costs are not additional to the costs considered in previous Sections. They merely make explicit the capital investment required to develop the facilities which would be used to deliver the outcomes discussed in previous sections.

Capital costs are shown separately for household waste, and for other waste streams, and for all streams combined. In all cases, the additional capital costs under ZWP are higher than those under BaU, reflecting the reduced reliance on landfill, and increasing reliance on both biological treatment, and non-landfill residual waste management.

Over the period examined, the additional capital cost of the ZWP Scenario for all waste streams is of the order £472 million (see Figure 29 and Figure 28). The total capital requirement for ZWP is around £1.16 billion (see Figure 29).

The additional facilities required to manage household waste are likely to incur an additional capital requirement of around £350 million (see Figure 24 and Figure 25), the total figure being £490 million (see Figure 25). For local authorities, it may well be that much of the funding of the capital is supported through 'gate fee' type payments, so that the costs of supporting infrastructure effectively come from revenue spending rather than capital budgets. Much depends on how the relevant facilities are to be procured.

5.6.1. Household Facilities

Figure 24: Infrastructure Capex - BAU (household waste only)

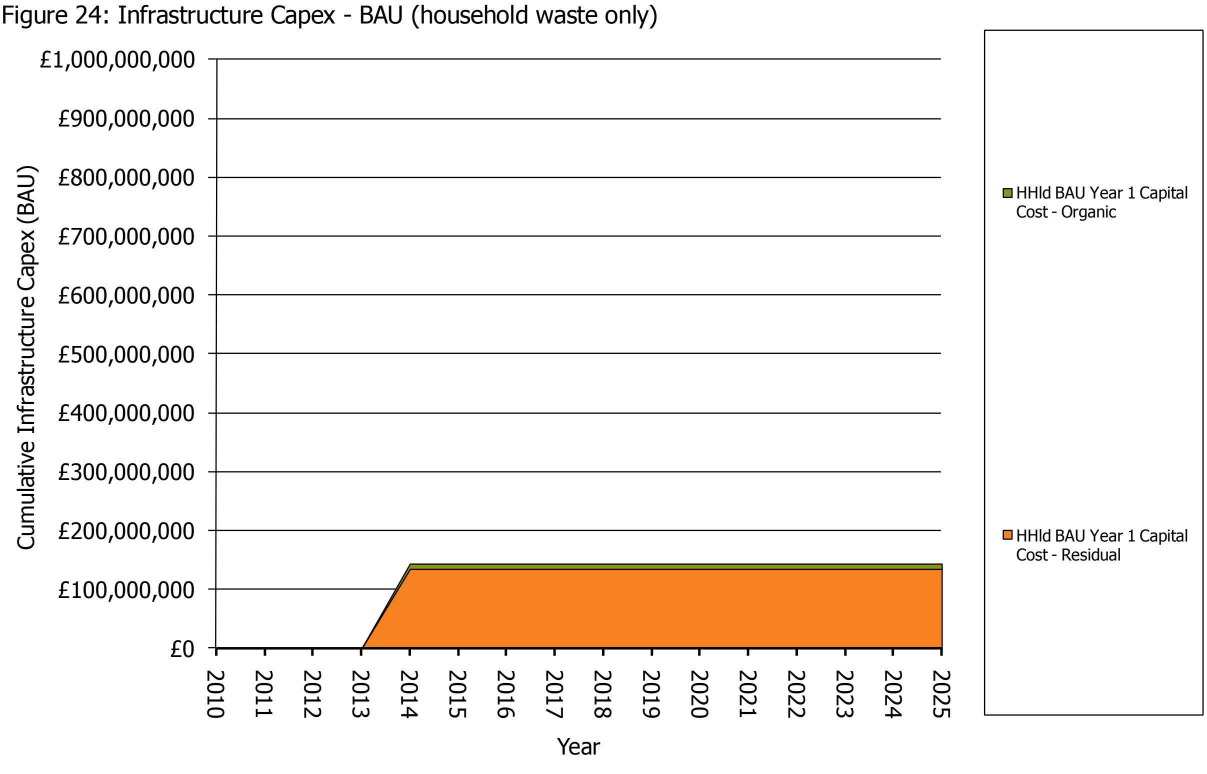
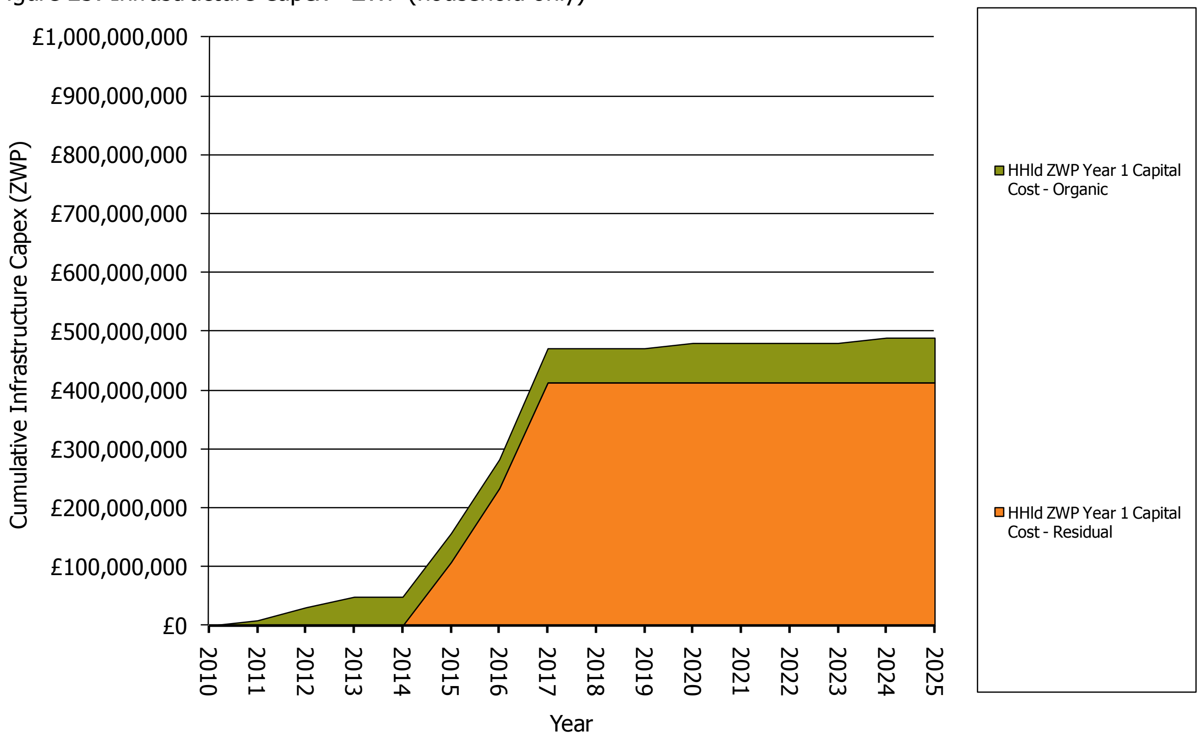


Figure 25: Infrastructure Capex - ZWP (household only)



5.6.2. Merchant (non-household) Facilities

Figure 26: Infrastructure Capex - BAU (Merchant Only)

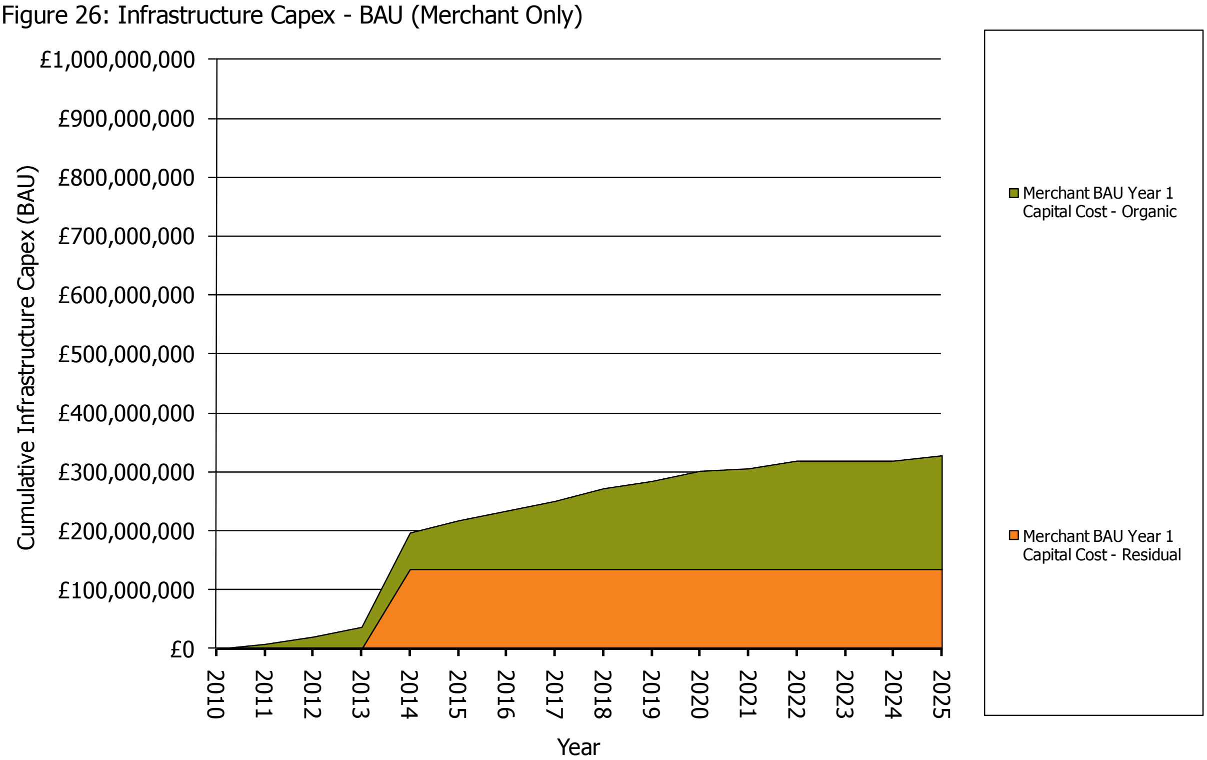
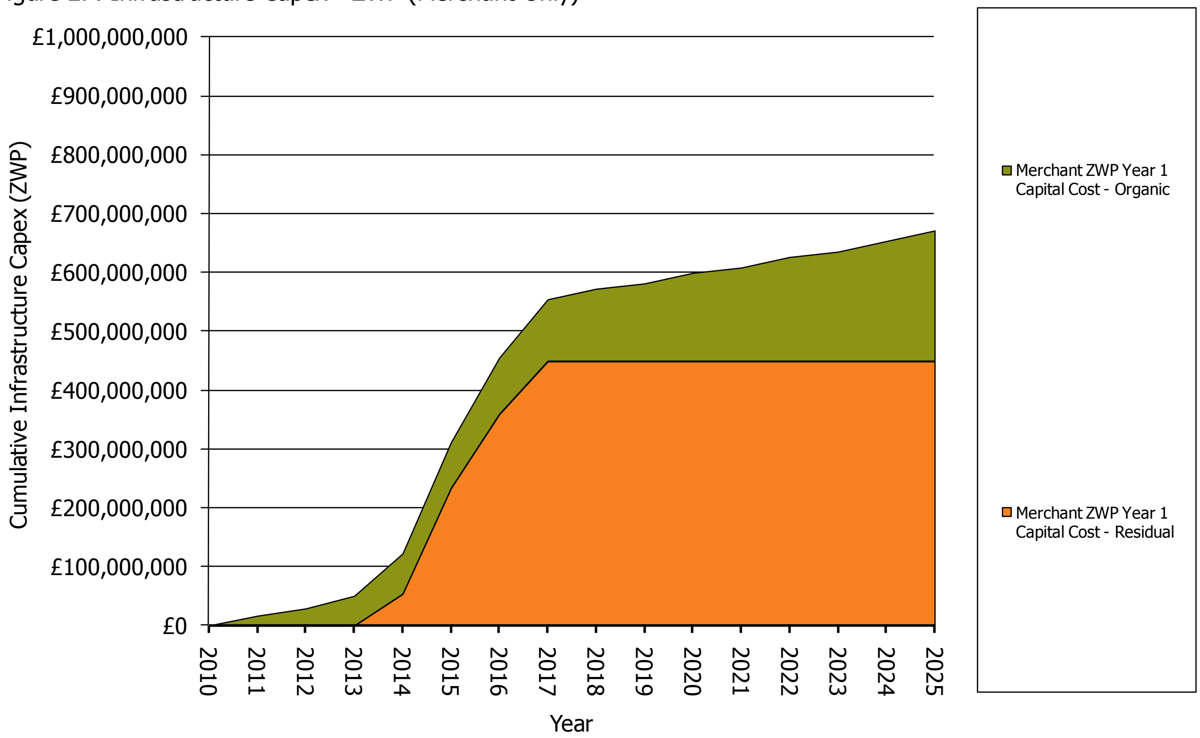


Figure 27: Infrastructure Capex - ZWP (Merchant Only)



5.6.3. All Facilities

Figure 28: Infrastructure Capex - BAU (LAC + Merchant)

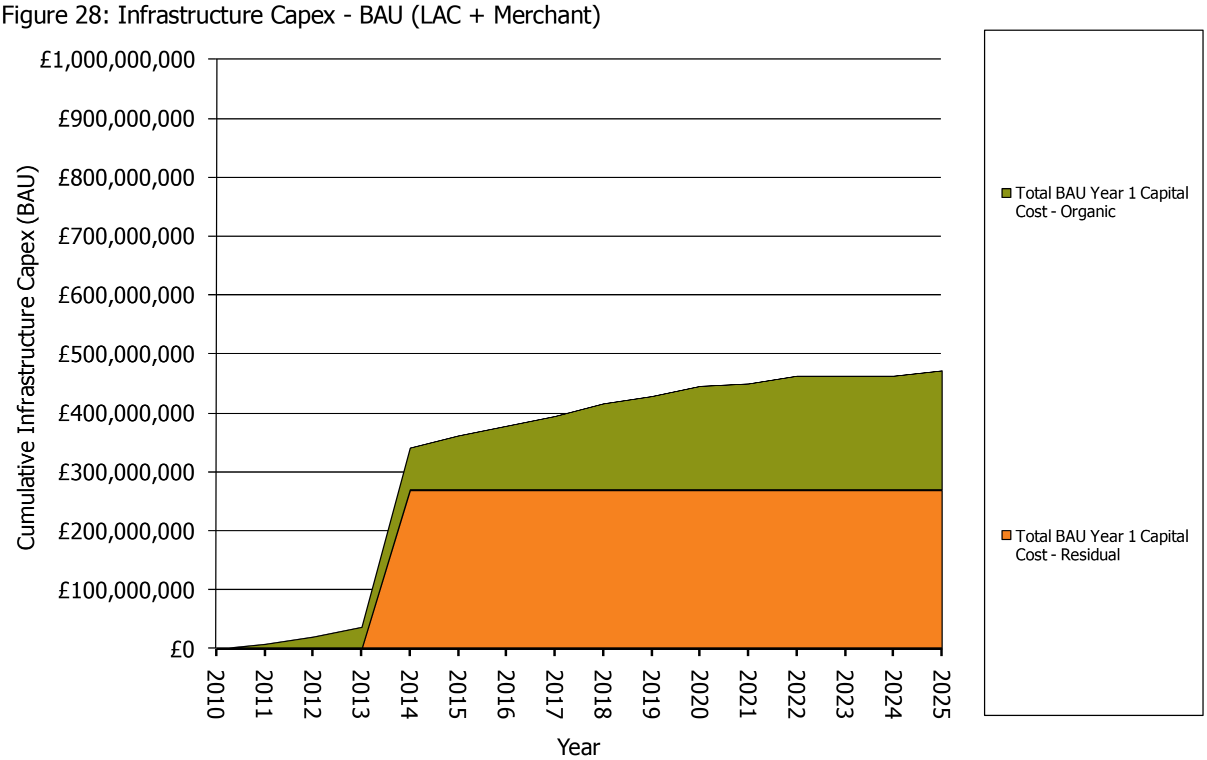
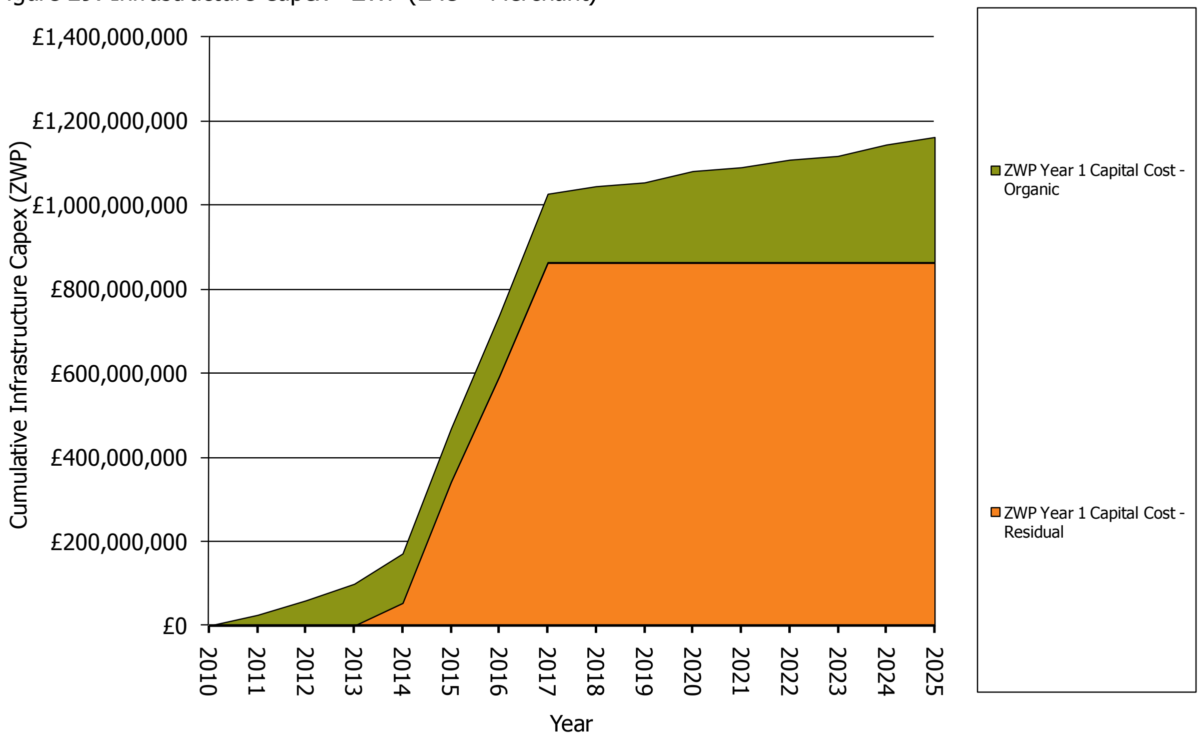


Figure 29: Infrastructure Capex - ZWP (LAC + Merchant)



5.7. Environmental Costs

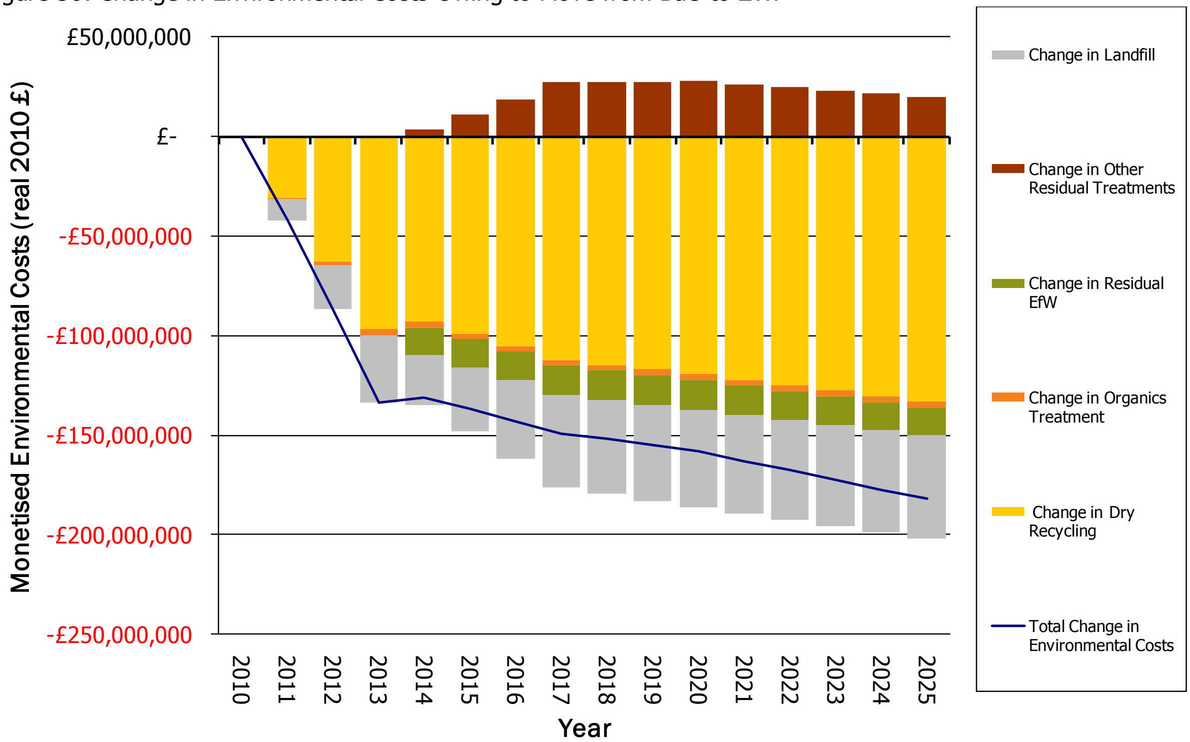
The environmental costs for the switch from BaU to ZWP are shown in Figure 30. The raw data is displayed in Table 25. This shows the environmental costs over and above the BaU Scenario. The figure shows contributions from the change in quantities of material sent to one or other form of waste management process. In the Figure, a negative figure denotes a negative cost (i.e. a benefit).

The Figure indicates that the monetised benefits exceed £180 million per annum following full implementation of the ZWP as envisaged. It also shows that by far the greatest benefit comes from the additional recycling of dry recyclables (around £135 million, or close to 75% of the total benefit). The next largest contribution comes from the avoidance of landfilling. The next largest benefit is associated with the treatment of organic wastes (around £52 million in 2025). There is some overlap between the benefits associated with the avoidance of landfilling and those with the treatment of organic waste. When material is separately collected for biological treatment, landfilling is avoided, and the benefits of biological treatment are secured. Hence, collecting biowaste contributes much to, but does not account for all, the benefits of avoiding landfilling because of the implied removal of biodegradable material from landfill.

The switch into alternative residual waste treatments does incur some environmental costs, but these are typically lower than those avoided in the switch away from landfilling. The alternative treatments generate costs of around £20 million in 2025 (note that these costs are assumed to be related to a mix of residual waste treatments, not to any specific process).

Part of the environmental benefits of the switch to ZWP relate to savings in the emissions og greenhouse gases (GHGs). In the later years, as illustrated in Figure 31, the GHG savings from the ZWP scenario compared to the BAU scenario exceed 2.5 million tonnes per annum, which is equivalent to taking 791,139 cars off the road.

Figure 30: Change in Environmental Costs Owing to Move from BaU to ZWP



Note: Negative figures imply a benefit. Please also to note that the benefit from residual EfW is a result of a reduction in EfW capacity whilst the cost from change in other residual waste treatments is a result of an increase in capacity.

Figure 31: Effects on Greenhouse Gas Emissions of Switching from 'Business as Usual' to Zero Waste Plan (negative numbers denote reduced emissions)

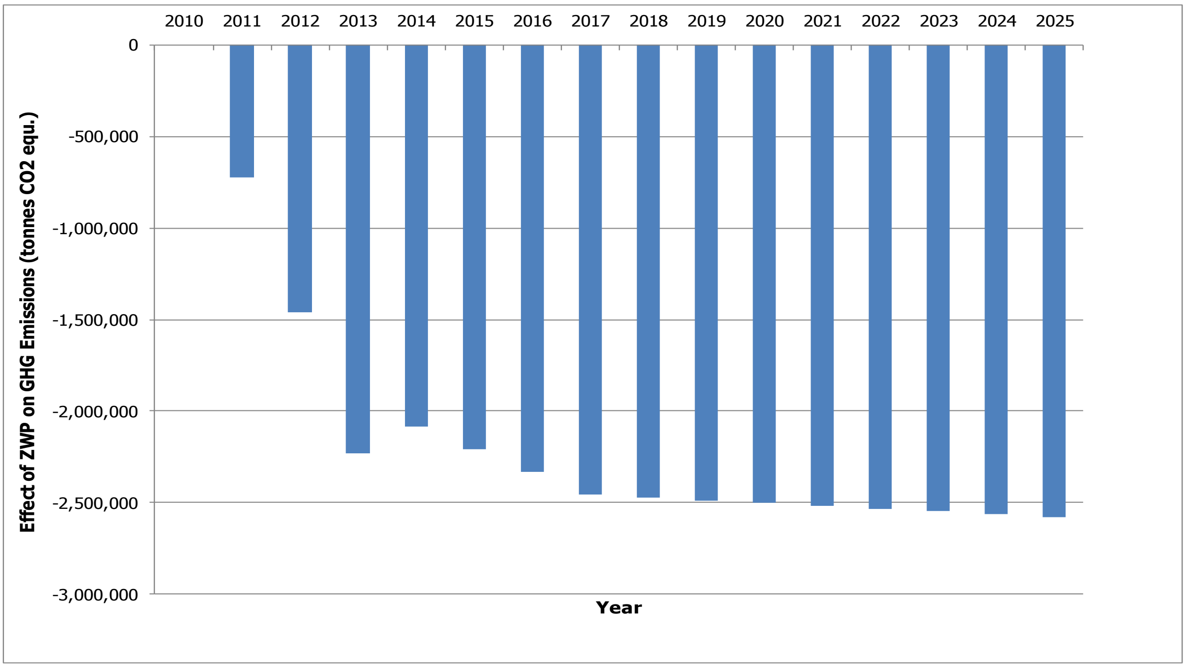


Table 25: Environmental Costs of Switching from BaU to ZWP (real 2010 £, millions)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Change in Dry Recycling	£0.00	-£30.83	-£62.34	-£95.10	-£90.66	-£94.86	-£99.03	-£103.53	-£103.84	-£104.16	-£104.48	-£104.79	-£105.11	-£105.43	-£105.75	-£106.08
Change in Organics Treatment	£0.00	-£0.98	-£1.99	-£3.03	-£2.64	-£2.61	-£2.59	-£2.56	-£2.54	-£2.52	-£2.49	-£2.47	-£2.44	-£2.42	-£2.40	-£2.37
Change in Residual EfW	£0.00	£0.00	£0.00	£0.00	-£12.74	-£12.70	-£12.66	-£12.62	-£12.58	-£12.54	-£12.50	-£11.85	-£11.20	-£10.55	-£9.90	-£9.25
Change in Other Residual Treatments	£0.00	£0.00	£0.00	£0.00	£2.93	£10.01	£17.01	£24.49	£24.30	£24.11	£23.91	£21.85	£19.80	£17.76	£15.75	£13.75
Change in Landfill	£0.00	-£11.70	-£23.66	-£36.04	-£27.33	-£33.38	-£39.41	-£45.78	-£45.34	-£44.89	-£44.45	-£44.01	-£43.57	-£43.12	-£42.68	-£42.24
Total Change in Environmental Costs	£0.00	-£43.51	-£87.99	-£134.17	-£130.43	-£133.54	-£136.68	-£140.01	-£140.01	-£140.01	-£140.01	-£141.27	-£142.52	-£143.76	-£144.98	-£146.19

5.8. Summary

In the central case modelled in the Section, changing from BaU to ZWP has the following effects:

Financial Costs

For the waste stream as a whole, there are net savings generated. Because, in the Central Case, we have assumed that the costs of residual waste treatment are the same as for landfill from 2014, the switch in waste away from landfill and into other residual waste treatments is, by and large, cost neutral. Additional recycling under the requirement to sort key dry recyclables and food, however, delivers net financial savings. These are most significant for the household waste stream, but there are some savings associated with the C&D stream also. It should be recalled that these savings are being considered against a backdrop of an £80 (nominal) landfill tax.

The ZWP implies the need for around £1.16 billion in terms of capital investment over the fifteen year period examined. This is an increase of around £472 million relative to BaU. For local authorities, the effect is to increase the requirement for capital infrastructure, or access to such infrastructure (local authorities do not need to fund the capital investment directly, and may use revenue spend to access / support the investment in facilities) from around £140 million to £490 million over the fifteen year period.

Environmental Benefits

As would be expected, the ZWP delivers environmental benefits over and above those from BaU. These additional environmental benefits are of the order £180 million. The key contributing elements are:

1. The increase in recycling of dry recyclables;
2. The avoidance of landfill; and
3. The increase in organic waste treatment.

6. Other Key Issues

6.1. Other Key Issues

As noted above, the modelling which has been carried out incorporates a range of assumptions. Before moving into the sensitivity analysis, we consider those that relate to the residual waste treatment market and potential exports of waste, as well as issues pertaining to the waste collection market, especially for commercial wastes (and to a lesser extent, industrial wastes also).

6.2. Assumptions Regarding Residual Waste Treatment Costs / Export Markets

One of the important assumptions relates to the effect of the landfill tax on the management of wastes under the BaU Scenario. The effect of the rising tax has been modelled as implying, essentially, an increase in recycling and a reduction in landfill, with some additional residual waste treatment where this is already in the process of construction

In reality, at the level the tax will reach in 2014/15, it is very difficult to model, with great certainty, the behaviour of the residual waste treatment market. At lower rates of landfill tax, a range of recycling options are available at lower cost than landfill, and for some wastes, there are also treatment options which are either 'necessary' or lower in cost. For much of the remaining residual waste, however, at low rates of tax, few residual waste treatments can compare with landfill on cost alone. The exception appears to be older incineration facilities, which are able to treat waste at a cost of around £40 per tonne, but such facilities are not to be found in Scotland, and in any case, most of these are reaching the date when they need to be retrofitted or replaced.

At £80 per tonne tax, many alternative residual treatments are of a comparable cost. This is highlighted in Table 13 above. It is also, by and large, reflected in the costs from survey work for WRAP regarding gate fees for such facilities.[80] It is not clear what the gate fees charged by proposed facilities are (or will be) as operators are generally reluctant to give out such information (on existing facilities also) due to perceived commercial sensitivities. The gate fees are expected to be higher, not lower, than for existing facilities with some possible exceptions (such as a gasifier successfully operating with a gas engine – as opposed to a steam turbine - and benefitting from double ROCs, a solution which has hitherto proven elusive on a commercial basis for mixed residual waste, even when a global view is taken). Even so, factors such as energy prices can influence costs (net of revenues) significantly for some facilities.

In addition to the cost of alternative treatments the cost of landfill could also change over time. The research in the study has shown that the gate fees in the central belt of Scotland are some of the lowest in the UK. However, to further fill void space operators may further drop gate fees to ensure the supply of waste to the landfill. A contrasting view is that operators may have to raise costs in the medium term to cover costs as the supply of waste falls (operators need to fund operation *and* aftercare from revenues generated in the operational phase).

Additional factors affecting the market include the potential to export residual waste for recovery to other EU Member States for recovery. The treatment markets in Northern Europe are experiencing somewhat chronic over-capacity, and gate fees have fallen in recent years, with operators from Germany, Netherlands and Sweden, amongst others, actively marketing capacity in the UK. The gate fees offered are sufficiently low that even allowing for transfer (and double handling within that), some facilities may look quite attractive from some locations in Scotland. At £80 per tonne tax, the costs of shipping residual waste for recovery on the continent may well be lower in real terms than landfilling in Scotland.

These factors do not simply affect the way residual waste is treated. They also affect the extent to which materials are recycled / re-used (as well as the strength of any incentive for waste prevention). Our BaU modelling is predicated upon increases in recycling owing to rising levels of avoided disposal cost. If residual waste treatments are available at costs lower than the landfill gate fee plus tax, then the costs of residual waste management which are avoided by the competing 'higher in hierarchy' activities are reduced. This would have the effect of depressing recycling rates (and there is some tentative evidence that this may well be happening in Germany, where the excess capacity for residual waste treatment is of the order 4.5 million tonnes).

To illustrate the potential significance of these points, we seek to outline below

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[80] *Eunomia has conducted this survey on behalf of WRAP for four consecutive years and has built a very strong evidence base concerning these facilities.*

a) What we have done in the Central Case;
b) The effect of changing these assumptions; and
c) The proposed approach to sensitivity analysis undertaken in Section 7 below.

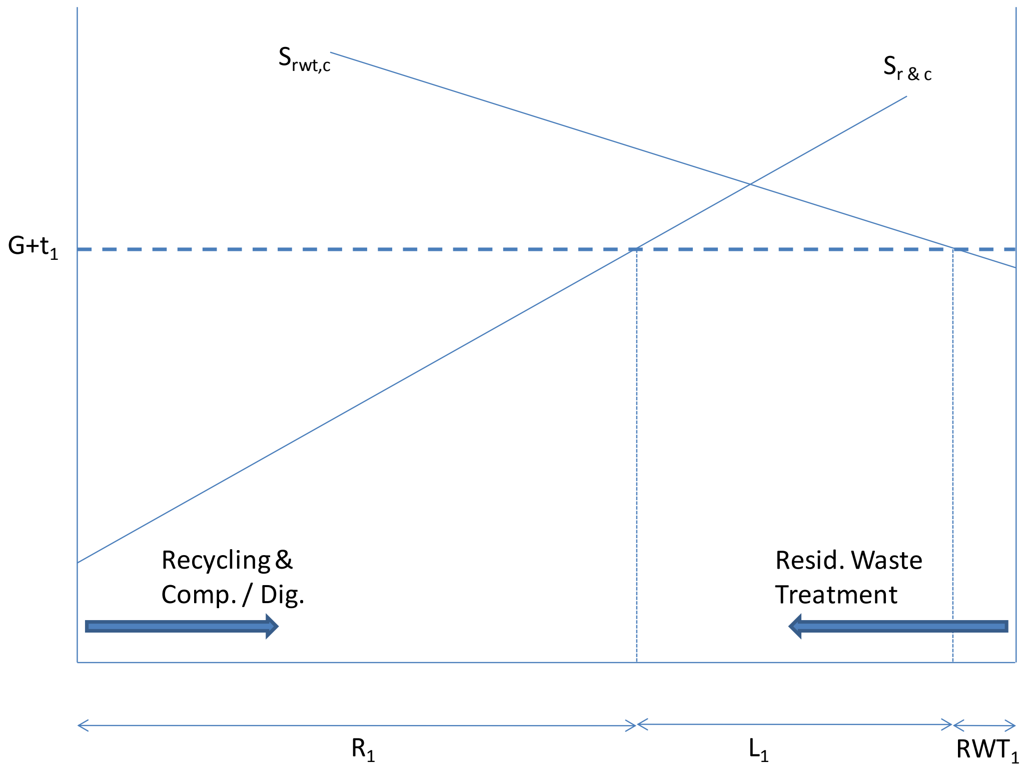
6.2.1. Current Approach

In the existing approach, we have assumed that those who are seeking to offer residual waste treatment capacity at costs competitive with landfill on a merchant basis are already likely to be in the planning process. Due to the extended periods of time these facilities can take to become fully operational (over 7 years in some cases), then given also the period already elapsed between the announcement of the tax rising to £80 per tonne and the current period, we have taken the view that, in terms of household and commercial waste, the only increase in treatment capacity which is motivated by the level of the £80 tax is what is already known about. For household waste, this amounts to an additional capacity of around 320,000 tpa, or 16% of Scotland's waste.[81]

Other than these facilities, therefore, we have assumed that landfill tax is the benchmark figure for 'avoided disposal' which drives increases in recycling under BaU. The current situation, therefore, resembles the one depicted (albeit in simplified form) in Figure 32. Here, the supply curve for recycling (S r&c), composting and digestion is drawn from left to right, with the usual upward sloping form. The supply curve for non-landfill residual waste treatment is drawn from left to right (S rwt,c). The 'c' denotes the assumption of a 'closed' waste economy (i.e. one not affected by the prices offered overseas).

The demand for both types of service is effectively depicted as the pre-tax gate fee landfill (G) plus the tax level (here shown as t_1). At this level of tax, the outcome is that R_1 percent of waste recycled / composted / digested, and RWT_1 percent of waste dealt with through non-landfill residual waste treatment. The balance ($100 - R_1 - RWT_1$) percent, or L_1, is assumed to be landfilled.

Figure 32: Current Approach to Modelling Supply and Demand for Recycling / Composting / Digestion and Non-landfill Residual Waste Treatment

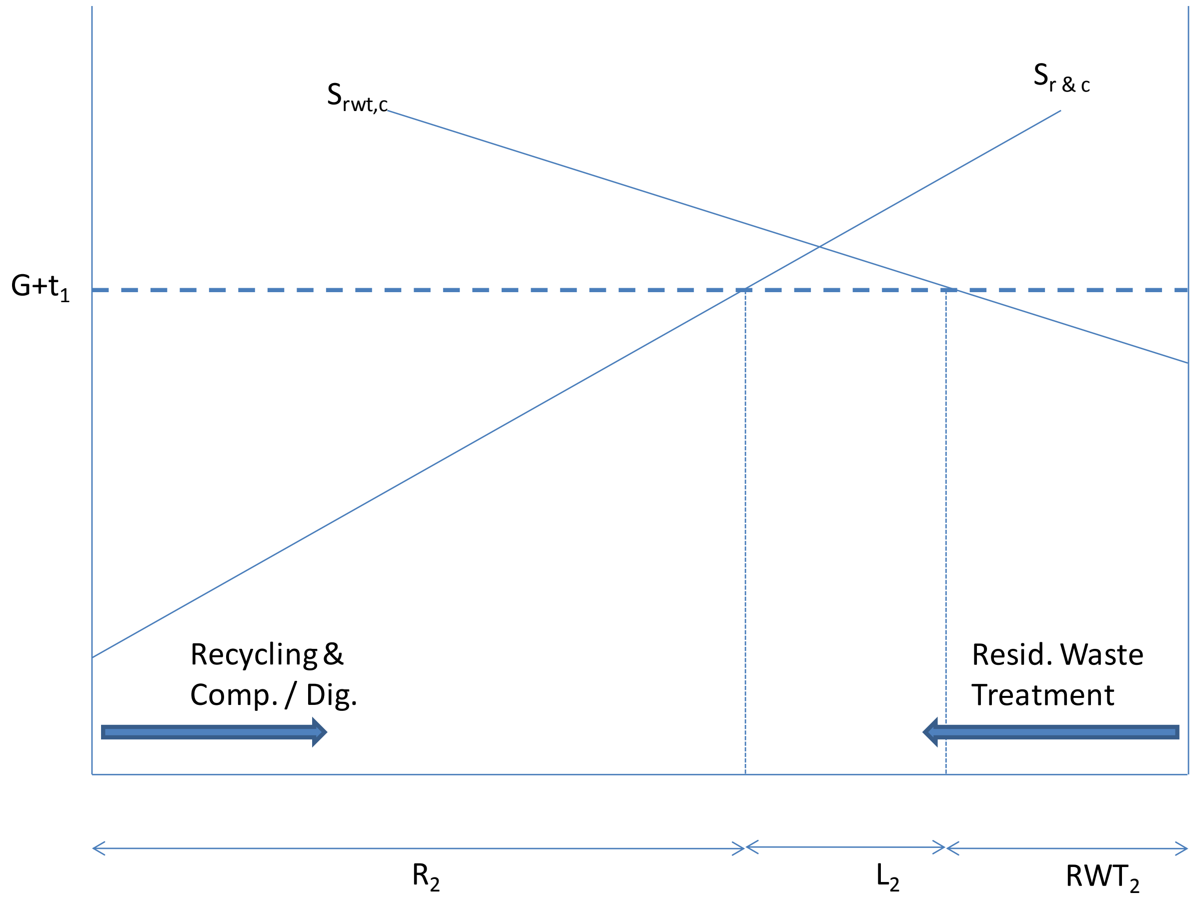


[81] *Scottish Futures Trust (2011) Untitled* http://www.scottishfuturestrust.org.uk/docs/262/File%206%20-%20Copy%20of%20Project%20Data%20-%2014%20Dec%202010.pdf

6.2.2. Relaxing the Assumption – Costs of Residual Waste Treatment are Lower than Expected

Suppose that our assumptions have over-stated the costs of non-landfill residual waste treatment. What might this mean for the modelling of the BaU Scenario? In principle, it means that the proportion of residual waste treated through residual waste treatment in response to the tax is too low. If the supply curve for residual waste treatment is lower than has been assumed, then the quantity dealt with through such means would be higher, and the landfilled quantity would be lower. In the case depicted in Figure 33 below, however, the recycling / composting / digestion remains as before, at R1. This is because in the case depicted below, the supply curve for recycling/composting/digestion and the supply curve for residual waste treatment, do not cross below the value of landfill plus tax ($G + t_1$).

Figure 33: Supply and Demand for Recycling / Composting / Digestion and Non-landfill Residual Waste Treatment (RWT), Reduced Costs for RWT, Closed Economy

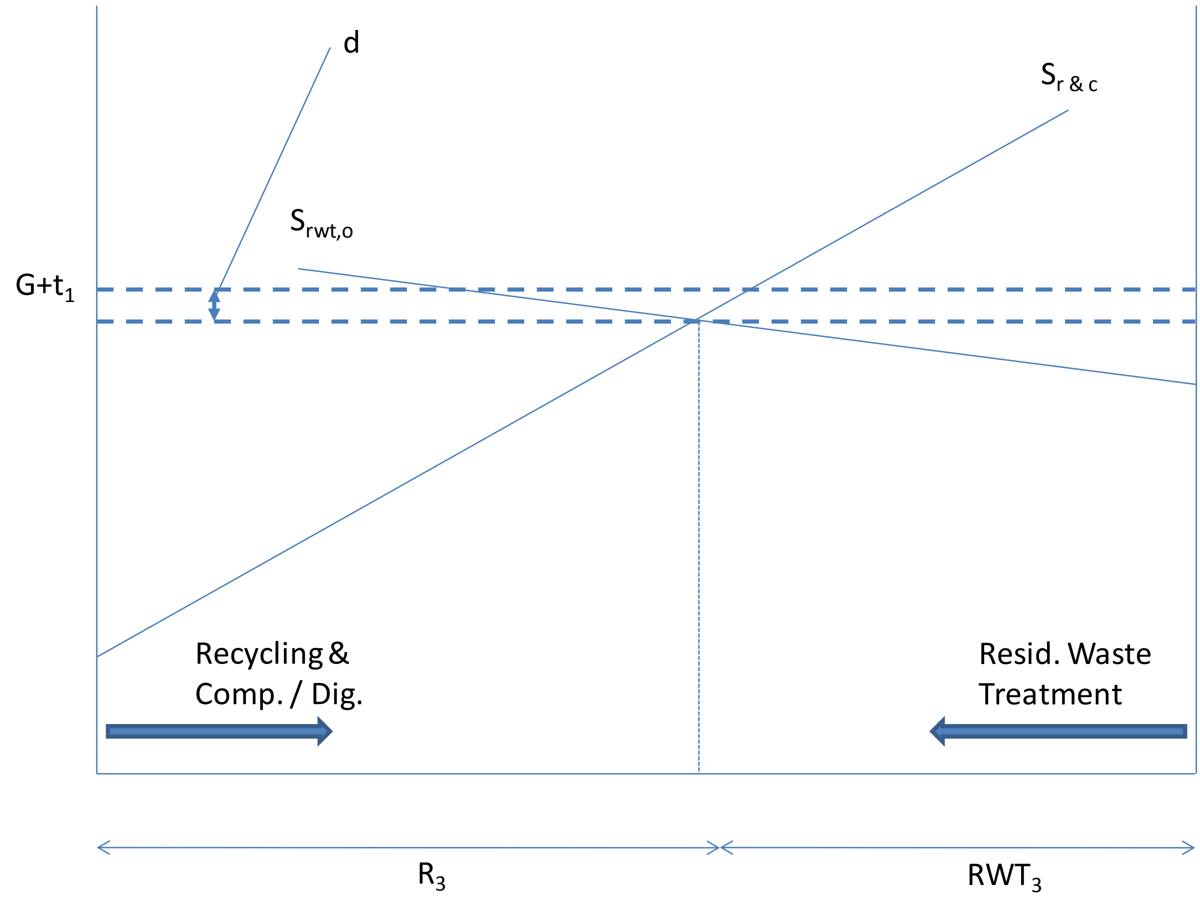


6.2.3. Relaxing the Assumption – Supply Curve for Residual Waste Treatment Flattens

The significance of the effect of relaxing our assumptions is made more significant where the supply curve for recycling/composting/digestion and the supply curve for residual waste treatment cross below the value of landfill plus tax ($G + t_1$) (see Figure 34). This could be the case, for example, where one assumes that the residual waste treatment market is effectively an open one, and where exports to third countries can happen at competitive prices. In this case, we denote the supply curve with a suffix 'o' instead of 'c' to denote the open economy assumption.

Effectively, the supply curve for residual waste treatment rotates anti-clockwise. The key observation here is not only that the quantity of residual waste treatment increases further, but that the increase in non-landfill residual waste treatment is such that there is a reduction in the quantity of waste which is sent for recycling / composting / digestion. Effectively, what happens is that instead of landfill providing the benchmark figure for the avoided cost of residual waste management, this benchmark is supplanted by the cost of residual waste management, reducing the avoided costs of residual waste management by an amount 'd'.

Figure 34: Supply and Demand for Recycling / Composting / Digestion and Non-landfill Residual Waste Treatment (RWT), Reduced Costs for RWT, and Open Economy



As can be seen there are many factors affecting the residual waste treatment market. The sensitivity of outcomes to the assumptions made is likely to be quite important not least since at £80 per tonne landfill tax, the incentive to build residual waste treatment facilities is not 'utterly compelling' (in the face of the commercial risks involved) but neither could it be considered completely foolish. There is a general feeling that the market is at a tipping point where waste will switch from landfill to other residual treatments. Even so, pushing successful projects through planning and financing remains challenging. Consequently, modelling the baseline and any scenarios which have marginal changes above this baseline is sensitive.

6.2.4. Implications for the Modelling

The effect on the results of relaxing assumptions in the manner we have outlined above would be:

i. To reduce the rate of recycling under BaU, and hence increase the effect which the ZWP would have on waste management);
ii. To reduce the costs of collection under BaU, and hence, increase the costs of any increases associated with ZWP);
iii. To reduce the costs of residual waste treatment under BaU, but also to reduce the costs associated with the switch of residual waste from landfill to alternative treatments under ZWP.

It makes sense, therefore, to explore the effects of changing our assumptions regarding residual waste treatment costs. As well as modelling a lower costs of residual waste treatment, we have also modelled a higher one. The Treatment costs assumed were outlined in Table 13 above, and the results of the analysis are given in Section 7.3 below.

6.3. Market Failure in the Waste Collection Market

There are good reasons to suppose that markets for waste collection may not function perfectly. We have discussed this at some length in other work.[82] There are a number of market failures which can reduce the efficiency of its operation, including:

i. Those associated with less than perfect information (regarding prices, and the availability / price of services);
ii. Those associated with network effects (in the commercial market in particular, the existence of open competition tends to have the effect of increasing costs and reducing margins for a given service configuration); and
iii. Those related to access to some services related to the institutional make-up of the market.

Our model starts from an assumption that the market is 'economically rational' to the extent that materials which are most expensive to collect are only collected when it makes economic sense to do so. The model includes a mechanism which allows one to 'bound' this rationality to reflect the fact that, for example, services might be under-supplied (or under-used) at a given level of avoided disposal cost because participants in the market cannot have certainty that new services will be utilised to an extent that makes them viable, or because would-be users are not aware of the potential to save money from the use of alternative services.

The way this works in the model is to assume that the level of recycling performance that is delivered is not that which would prevail at a given rate of landfill tax, but that which would prevail at the given rate minus an assumed figure. This figure can be varied across the BaU and ZWP Scenarios, and under ZWP, we assume a somewhat more rational market for recycling services for those materials targeted by the Regulation regarding mandatory sorting. The reasoning for this is that we suspect that the market failures lead to a 'lower than would be rational' uptake of recycling services by businesses. The ZWP effectively overcomes this by stimulating people to do things which are ultimately in their own economic interest to undertake. This functionality is applied only for the commercial and industrial waste sectors. The degree to which our assumptions do, or do not, reflect the prevailing reality is difficult to be sure of. However, we believe this represents a novel way of building in an effect of the policy which we expect to be made manifest if the policy is indeed enacted.[83]

Novel or not, it is clear that the assumption that has been made in the Central Case presented in Section 5– of a 'slightly less than perfectly rational market' – might not be the right one. It is proposed, therefore, to undertake sensitivity analysis around this 'level of rationality' assumed under the BaU case. As with residual waste treatment costs, the sensitivity analysis has been undertaken for a higher and a lower level of rationality than has been assumed under the Central Case. Under the High rationality scenario, the market responds to the incentive of the landfill tax so that commercial waste recycling reaches 62%. Under the Central Case (already presented above) the recycling rate for commercial waste is 57%. In the Low rationality case, the response to price is more sluggish, and commercial waste recycling rate is only 52%.

6.4. Timing of the Introduction of the Regulations, Central Case

There is a delicate matter of the sequencing of the ZWP Regulations to be considered. In the Consultation on the Regulations, it was expected that the requirement to sort might enter into force in 2013 and that the ban on landfilling of untreated waste would enter into force in 2017.

There are a number of considerations which it would seem are important to take into account when setting the date (and considering the detailed design of) these Regulations. The detailed design issues are not a matter for this work, but it seems pertinent to consider how the timing of implementation might affect the outcomes.

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[82] *L. Franckx, M. Van Acoleyen, D. Hogg, A. Coulthurst and A. Holmes (2008)* Optimising Markets for Recycling*, Final report to The European Commission – DG Environment, August 2008; Eunomia (2009)* Economic Assessment of the Market for Waste Management in Wales*, Final Report to the Welsh Assembly Government, July 2009.*

[83] *There is clear evidence that in England, several collection companies sought to make customers clear of their obligation to pre-treat waste as a consequence of the coming into force of the pre-treatment requirements of the Landfill Directive. Not all of this would have been motivated by the desire to deliver a more efficient service, to be sure, but this reveals how policies which require customers to sort their wastes might be used by actors in the market to support their offer of (new) services to (new) customers.*

6.4.1. Requirement to Sort Specified Materials

The key issues of significance for the timing of implementation of the requirement to sort specific materials are considered below.

Is enough time available for local authorities to make changes in their existing arrangements (collection and treatment / disposal) without incurring excessive transaction costs?

For a number of authorities, the 'requirements to sort' could require some re-thinking of existing collection schemes (exactly what extent is a matter to be determined in the detail of the design of the Regulations). For those who contract out their collections, there may be scope to revise the system within an ongoing contract, but equally, this might pose difficulties, and in any case, might prove to be more costly in the short-term than would be desirable. That having been said, it might be expected that local authorities in Scotland are already adapting their arrangements when suitable occasions arise so as to take into account the likely shape of the obligations facing them, although, equally, the details of these are still not yet known (so local authorities continue to act in an environment of uncertainty). Mitigating actions could include:

1. Announce the Regulations, in their full detail, as early as possible;
2. Allow for a period of time to elapse before this takes full effect.

It should be noted that it is not only collection contracts that may have to be changed under the 'requirement to sort'. Those authorities who have signed 'put-or-pay' contracts with treatment providers would also have to renegotiate contracts. This process may take time, and depending upon the details of those contracts, revisions could prove to be costly. That having been said, few Scottish authorities are currently in this situation, and some may be able to negotiate relatively favourable changes, recognising that the ban on landfilling untreated waste will lead to an increase in demand for treatment capacity from other sources (so that to the extent that a contractor frees up capacity, it might actually be profitable for them to renegotiate, or at very least, they might seek to share risk with the authority on any headroom made available through the requirement to deal with greater tonnages through recycling and composting).

Is enough time available for the required biowaste treatment capacity to be developed?

The requirement to sort food waste places demands on Scotland to develop additional biowaste treatment capacity. Our modelling suggests that something of the order 1 million tonnes of food waste treatment capacity may be required if the requirement is such that high capture food waste collection systems become the norm. In principle, there is little point in developing the collection systems in the absence of the required treatment capacity. That having been said, the conditions for developing AD systems are, presently, rather good, at least in terms of support for energy generation in the form of electricity and heat (the rapidity with which markets could be developed for the outputs remains to be seen). We estimate that current and planned capacity for AD of food wastes is of the order 280,000 tonnes. In addition, current and planned capacity for IVC sites will (depending on the nature of the material mix) contribute additional capacity for food waste treatment (perhaps of the order 100,000 tonnes). This still leaves a considerable gap relative to what may need to be treated. The announcement of the Regulations is likely to trigger additional interest in developing capacity, but time to allow for this needs to be given.

It might be asked, in light of the above discussion, what would the consequences be of delaying the requirement for sorting food relative to the requirement to sort dry recyclables.. The emerging pattern of provision for food waste collection in the UK, however, appears to be that bidders either:

1. Opt to collect on the same vehicle as dry recyclables where they are engaged in 'kerbside sort' schemes; and
2. Opt to collect using refuse collection vehicles with pods behind the drivers cabin, with these collecting residual and recyclables on an alternating week basis (so as to provide a weekly food waste collection).

In both cases, the food waste collection service is intimately bound up with other parts of the collection service. We would argue, therefore, that such a delay is likely to incur additional costs in the collection phase as vehicles would either being running sub-optimally for a period of time, or would simply have to be replaced before the end of their life, once the food waste collection came in.

Summary

On balance, therefore, the above argument supports

a) Early announcement of the detail of the requirement to sort; and

b) Allowing sufficient time to elapse before the requirement is actively enforced so as to enable biowaste treatment capacity to be developed, and to allow for a smooth transition to the desired systems; but
c) Implementing the policy early, subject to b) above, so as to generate the benefits associated with the policy sooner rather than later.

The current proposal – to implement the requirement in 2013 – looks ambitious. There is a need to strike a balance between giving time to respond, and seeking speed of delivery of the benefit. There is a decision for policymakers to consider: do they seek to establish a date and stick to it with no flexibility given to local authorities, or do they seek to bring the date forward, but allow for some 'managed flexibility', whereby local authorities for whom transaction costs are high make requests to Government for time-limited 'derogations'? Each approach has its merits.

It should be noted that our modelling of financial costs does not include any estimate of the transition costs associated with the need, for example, to renegotiate contracts. It would be expected, however, that the shorter the time period given for the change, the higher those transition costs are likely to be.

6.4.2. Requirement to Pre-treat Residual Waste

The consultation on the ZWP Regulations envisages the requirement to pre-treat waste being in place by 2017. The key issues for consideration with regard to the pre-treatment requirement are considered below.

Flexibility to Respond to Changes in Residual Waste Quantities
Whilst landfill has many drawbacks as a means to manage residual waste, it does have the positive feature of being what one might term a 'stock facility'. This means that there is a supply of landfill void space which is relatively fixed, and which is progressively 'used up' over time. There is, however, no defined annual throughput related to the nature and size of the facility. Rather, the facility can be filled at varying rates with relatively limited consequences (within reason) for the economics of the operation.

All other means to deal with residual waste have associated with them some element which defines an annual capacity to treat waste (though in various cases, this can be flexed up to a point). These facilities might be considered 'throughput' facilities. Their economics is affected by the level of throughput, with the effect on plant economics being greater, generally speaking, where the capital cost per tonne of 'design capacity' are higher.

This means that as one moves away from landfill, one inevitably moves towards facilities whose economic viability is dependent upon achieving a respectable level of throughput relative to the design capacity. This also means that it is in the interest of market participants not to have a significant mis-match between the capacity to treat residual waste, and the quantity of residual waste being generated. Where the capacity is too low, then if sanctions are applied for non-compliance with the pre-treatment requirement, operators in the market for residual waste treatment may generate excessive rents on the spot market. The reverse is true where capacity is too great. In these circumstances, operators tend to lower prices for treatment to generate some additional revenue to cover costs. The effect of this is generally to undermine the market for waste prevention, re-use and recycling since the marginal benefits from avoiding the disposal / recovery of residual waste fall as a consequence of over-supply.

A general message of this discussion is that bans tend to be difficult to 'get right' as the situation in which the demand for, and supply of, residual waste treatment capacity are more or less balanced in all years is extremely difficult to achieve. Other things being equal, however, the likelihood of the market being better balanced will be enhanced where the requirement is imposed only once the major changes in prevention, recycling and re-use have been implemented, and their full ramifications are clear.

Two issues seem to be important, therefore:

1. The first relates to the extent to which overall waste arisings rise or fall over the period between the time of writing and the time the requirement to pre-treat is implemented. There is a considerable degree of uncertainty about how waste quantities will change in future years, especially in respect of commercial, industrial and construction and demolition wastes. If, as is possible, these decline significantly (as a consequence, for example, of the landfill tax, and other initiatives effecting behaviour beyond 2014), then it makes sense to ensure that the effect of these is well understood before requiring development of this capacity;

2. The second relates to the rates of recycling and re-use. It clearly makes no sense to implement a requirement to treat residual waste before all measures which are expected to have an effect on residual waste quantities have taken their full effect. In practice, this means that this measure should not be considered before the requirement to sort materials (discussed above) has had its full, expected effect.

The above, and the discussions regarding the requirement to sort above, suggest there may be a rationale to give effect to this measure only once two to three years – at least – have elapsed following the full implementation of the requirement to sort.

Development of Residual Waste Treatment Capacity
As with biowaste treatment capacity, there needs to be sufficient time available for the development of residual waste treatment capacity. Residual waste treatment facilities are known to take time to develop. They need to be procured, consented (in terms of planning permission and PPC permits), constructed and commissioned before they operate on a fully commercial basis. This process may vary in time for different facilities, but for some, it is likely to take seven years, perhaps longer.

Logically, this suggests that this Regulation might best be implemented no sooner than 2018. This is consistent with the suggestion above regarding the issue of flexibility of response to residual waste treatment.

Summary
In order both to:

1. Ensure, as far as possible, that issues of over-capacity in residual waste treatment do not arise; and
2. Allow for the development of residual waste treatment capacity,

It may be worth considering postponing the requirement to pre-treat waste to a year towards the end of this decade (2018-2020). This will allow for the development of the recycling and re-use envisaged under the ZWP. It may also give enough time for an improvement in data quality to allow for better forecasting of (residual) waste quantities going forward. The basis for such projections is not a solid one at present.

It is proposed to undertake sensitivity analysis of the timing of Regulations to understand the implications for the environmental and financial costs.

7. Sensitivity Analysis

In this Section, three sets of Sensitivity analysis are undertaken, each of which is described below. Many of the results are presented in terms of their Net Present Value. This is a way of presenting, in a single figure, the magnitude, in 'current money terms', of the flow of costs / savings over the period 2010-2025.

Timing

In the first, we explore how, under the Central Case, the financial costs and the environmental benefits of the switch from ZWP to BaU change as the timing of the introduction of key measures is varied. This is done only for the Central Case, for which the results have already been presented in Section 5 above. The Sensitivities considered are as follows:

1. Requirement to Sort in 2013, Requirement to pre-treat in 2017;
2. Requirement to Sort in 2013, Requirement to pre-treat in 2020;
3. Requirement to Sort in 2015, Requirement to pre-treat in 2017 ;
4. Requirement to Sort in 2015, Requirement to pre-treat in 2020; and
5. Requirement to Sort in 2018, Requirement to pre-treat in 2020.

It might be noted that under a fairly strict interpretation of the Waste Framework Directive, it could be argued that the last of these is non-compliant. Whilst the Directive requires, strictly speaking, only that separate collection be 'set up' for specific materials, the requirement – under Article 4 – to ensure that the waste hierarchy is reflected in policy and law would, taken together with the requirement to 'set up' collections, suggest that there should be an expectation that those collections should be used. A 'requirement to sort' might be inferred from the two relevant Articles.

Rationality in the Commercial (and Industrial) Waste Collection Market

In the second, variations in the extent to which actors are assumed to behave "rationally" in the BaU Scenario are considered. Two cases other than the 'moderately rational' Central case are considered, one where actors are 'weakly rational', the other, where they are highly rational. These are termed Low R and High R, respectively. Once again, the aim is to understand the effect of varying these assumptions on the financial costs and environmental benefits of the switch from BaU to ZWP.

Residual Waste Treatment Costs

In the third, we explore variants on the central case so that the costs of non-landfill treatment for residual waste are lower, and higher than the costs of landfill (including tax) in future. We called these the Low T and High T cases, respectively. The aim is to understand the effect of varying these assumptions on the financial costs and environmental benefits of the switch from BaU to ZWP.

The five sets of assumptions – regarding residual waste treatment costs and rationality - are set out in Table 26, which shows which pairs of assumptions were modelled. The Central Case for the study is that where we assume the Central Case for both the costs of residual waste treatment, and the rationality of the commercial waste market, prevail. This is the case already presented in Section 5.

Table 26: Sets of Paired Assumptions Used in Modelling Switch from BaU to ZWP

	Low T	**Cent T**	**High T**
Low R		Cent T, Low R	
Cent R	Low T, Cent R	Cent T, Cent R, **Central Case**	High T, Cent R
High R		Cent T, High R	

In these cases, it is assumed that the requirement to sort recyclables and food under the ZWP is introduced in 2013, and that the ban on waste to landfill – assumed to be implemented through a requirement to pre-treat waste to ensure it loses the majority of its ability to generate methane – is introduced in 2017.

7.1. Sensitivity with Respect to Timing

In order to understand the potential consequences of moving the implementation dates for the Zero Waste regulations, we have examined the overall costs and benefits of the move to ZWP under the following scenarios:

1. Requirement to Sort in 2013, Requirement to pre-treat in 2017;
2. Requirement to Sort in 2013, Requirement to pre-treat in 2020;

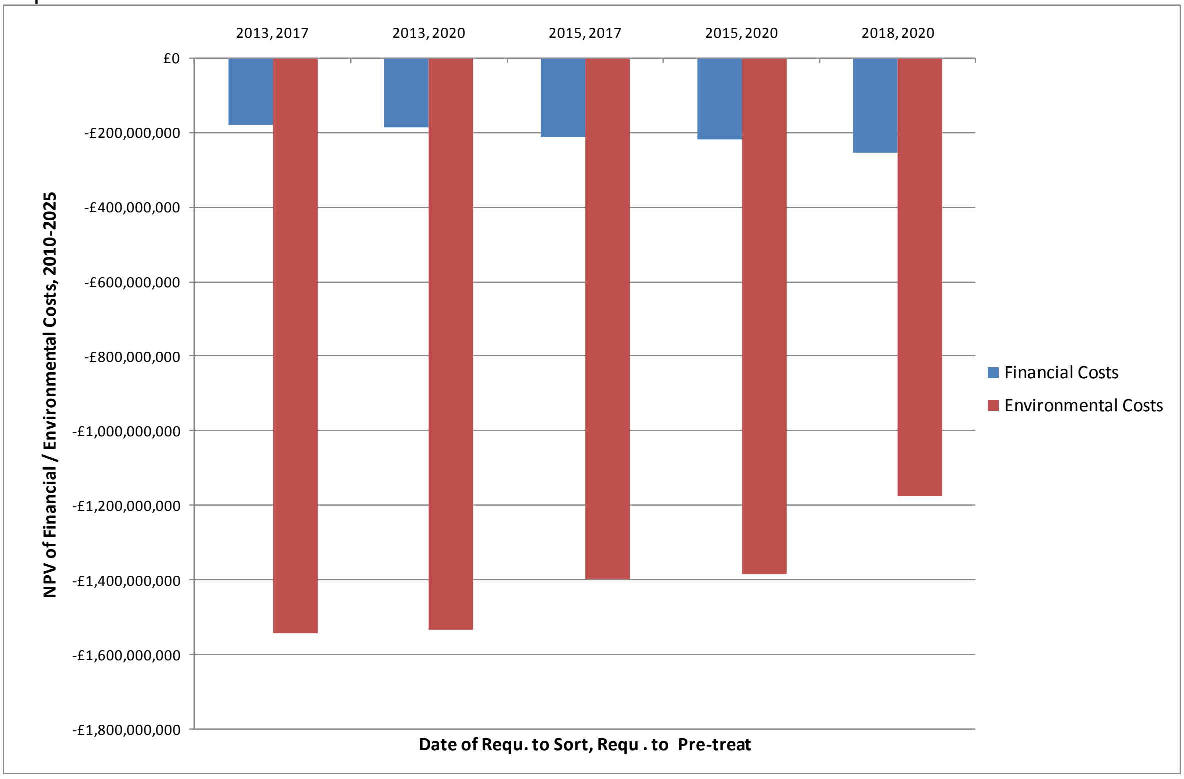
3. Requirement to Sort in 2015, Requirement to pre-treat in 2017;
4. Requirement to Sort in 2015, Requirement to pre-treat in 2020; and
5. Requirement to Sort in 2018, Requirement to pre-treat in 2020.

The key results are shown in Figure 35 and in Table 29. The key findings are:

1. The value of the environmental benefits generated declines as the requirement to sort moves back in time;
2. However, the financial savings increase as the requirement to sort moves back in time, but this increased saving is smaller than the extent of the reduction in environmental benefits;
3. The effect of moving the requirement to pre-treat back in time barely has any impact, but it reduces costs marginally but it also reduces environmental benefits (the effects seem small, and more or less balanced);
4. The effect on financial costs of the changes is less significant than the effect on environmental costs.

The suggestion is that the most important factor is the timing of the requirement to sort. In general, the financial savings are lower and the environmental benefits are higher as the requirement to sort is moved forward.

Figure 35: Financial and Environmental Costs of Different Timing Options for Introducing Requirement to Sort and Requirement to Pre-treat Waste



Note- positive figures represent costs/disbenefits, negative figures represent savings / benefits. Please note that the net present value is calculated from figures in which capital costs are already annualised.

Table 27: Net Present Value of the Change in Financial and Environmental Costs (from BAU to ZWP), 2010-2025, for Variants on Timing of Regulations (central case in italics)

Scenario	**NPV of Financial Costs (2010-2025)**	**NPV of Environmental Costs (2010-2025)**
Requirement to Sort in 2013, Requirement to pre-treat in 2017	*-£178 million*	*-£1,544 million*
Requirement to Sort in 2013, Requirement to pre-treat in 2020	-£186 million	-£1,533 million
Requirement to Sort in 2015, Requirement to pre-treat in 2017	-£211 million	-£1,398 million
Requirement to Sort in 2015, Requirement to pre-treat in 2020	-£218 million	-£1,387 million
Requirement to Sort in 2018, Requirement to pre-treat in 2020	-£255 million	-£1,177 million

7.2. Sensitivity with Respect to Rationality in the Commercial (and Industrial) Waste Collection Market

Variation in the nature of rationality has the effect shown in Table 28. The graphic representations of performance are shown in Figure 36 to Figure 41. It is important to note that – and Figure 38 and Figure 39 show this clearly – that changing the rationality affects the C&I sector only. The implications are, in essence, that a lower C&I recycling rate is achieved in BaU under the Low Rationality Case, and a higher one is achieved in the High Rationality Case, than in the Central case reported on in detail above.

The summary Table helps draw out the key messages, which are as follows:

1. In the Low Rationality Case, the effect of the shift to ZWP is to increase environmental benefits by around 3% relative to the Central Case. This is because the effect of the shift to ZWP is to pull a greater quantity of waste into recycling and composting / digestion than in the Central Case because the baseline level of recycling is lower where the rationality is lower in the BaU Scenario;
2. The opposite is the case for the High Rationality Case. The environmental benefits are reduced by around 7% relative to those in the Central Case. This is because of the better performance under BaU in the High Rationality Case;
3. Regarding financial costs, the savings generated by ZWP are greater in the Low Rationality Case than for the Central Case. This is because although more recycling needs to be done, more of it is done at a cost which generates savings for the service users (because they are effectively being stimulated to do things which they arguably should have been doing anyway, from the economic perspective);
4. Again, the opposite is true for the High rationality Case. Less additional recycling needs to be done, but more of it needs to be done at an additional cost to the service users (because they are already operating rationally under BaU); and
5. The changes in financial cost are smaller than the changes in environmental benefit. In the Low Rationality Case, the switch to ZWP costs much the same as the Central Case, but in the High Rationality Case, the change costs rather more than in the Central Case.

It is important to note that the end point under the ZWP is the same in each of these cases. What is being changed is the forward projection under BaU. The differences in costs relate, therefore, to assumptions regarding the effects of existing policy, not the end-points implied by implementing the ZWP.

Table 28: Net Present Value of Financial and Environmental Costs of Switching from BaU to ZWP, 2010-2025, Variants in Rationality

Case	**NPV of Financial Costs (2010-2025)**	**NPV of Environmental Costs (2010-2025)**
Low Rationality (Cent T, Low R)	-£185 million	-£1,589 million
Central (Cent T, Cent R)	-£178 million	-£1,544 million
High Rationality (Cent T, High R)	-£123 million	-£1,432 million

Figure 36: Financial Costs of ZWP relative to BaU, Case with Low Rationality in BaU (Central Treatment Costs) (real 2010 £)

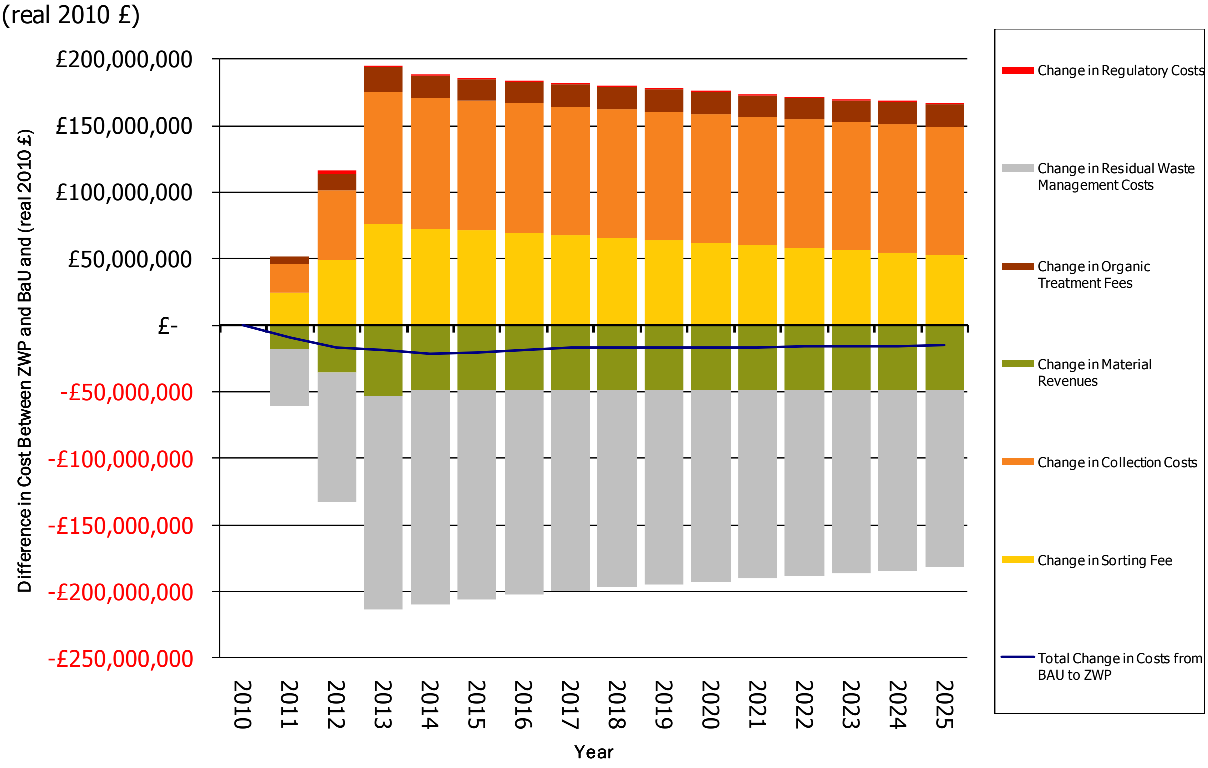


Figure 37: Financial Costs of ZWP relative to BaU, Case with High Rationality in BaU (Central Treatment Costs) (real 2010 £)

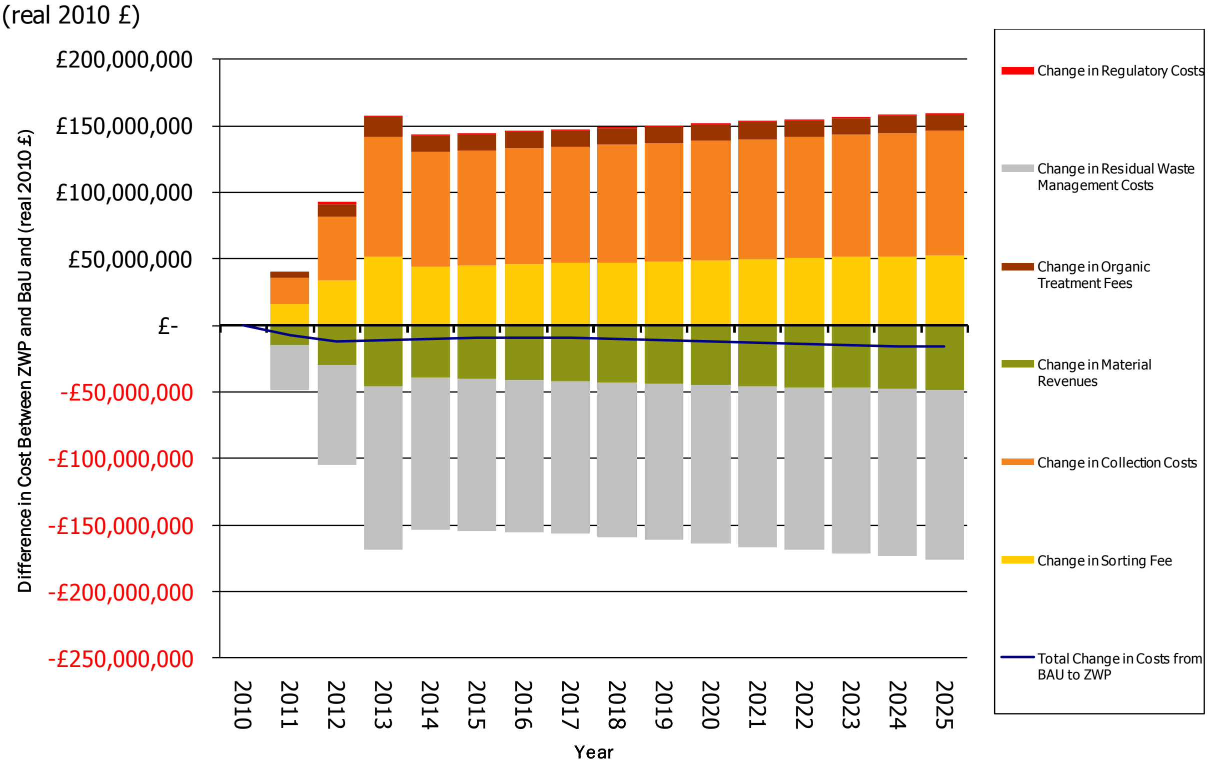


Figure 38: Financial Costs of ZWP relative to BaU, Case with Low Rationality in BaU (Central Treatment Costs), Sectoral Split (real 2010 £)

Figure 39: Financial Costs of ZWP relative to BaU, Case with High Rationality in BaU (Central Treatment Costs), Sectoral Split (real 2010 £)

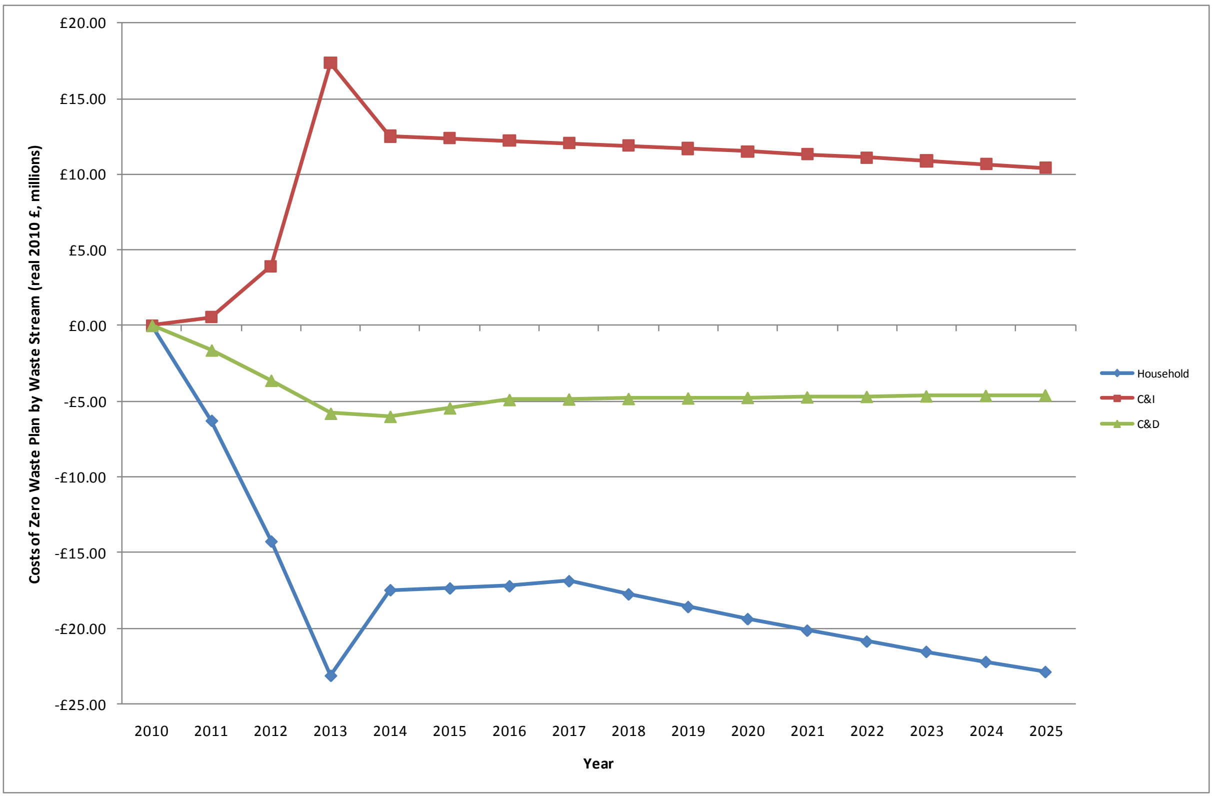


Figure 40: Environmental Costs of ZWP relative to BaU, Case with Low Rationality in BaU (Central Treatment Costs) (real 2010 £)

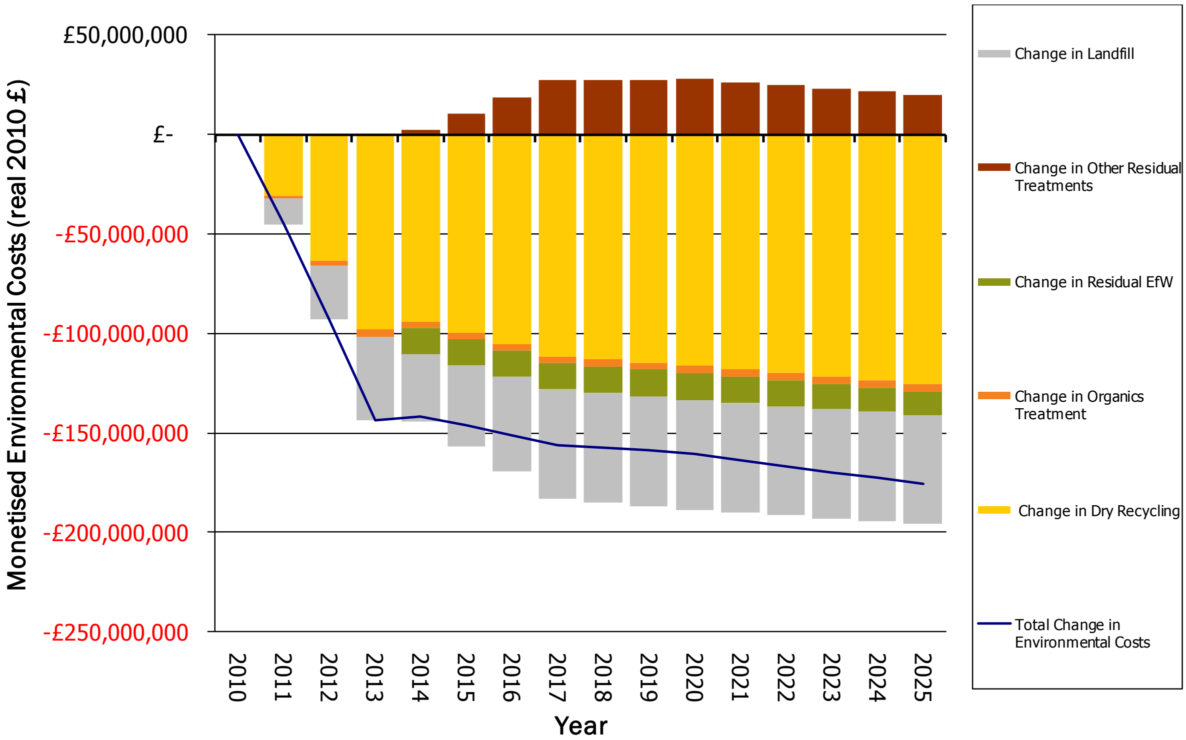
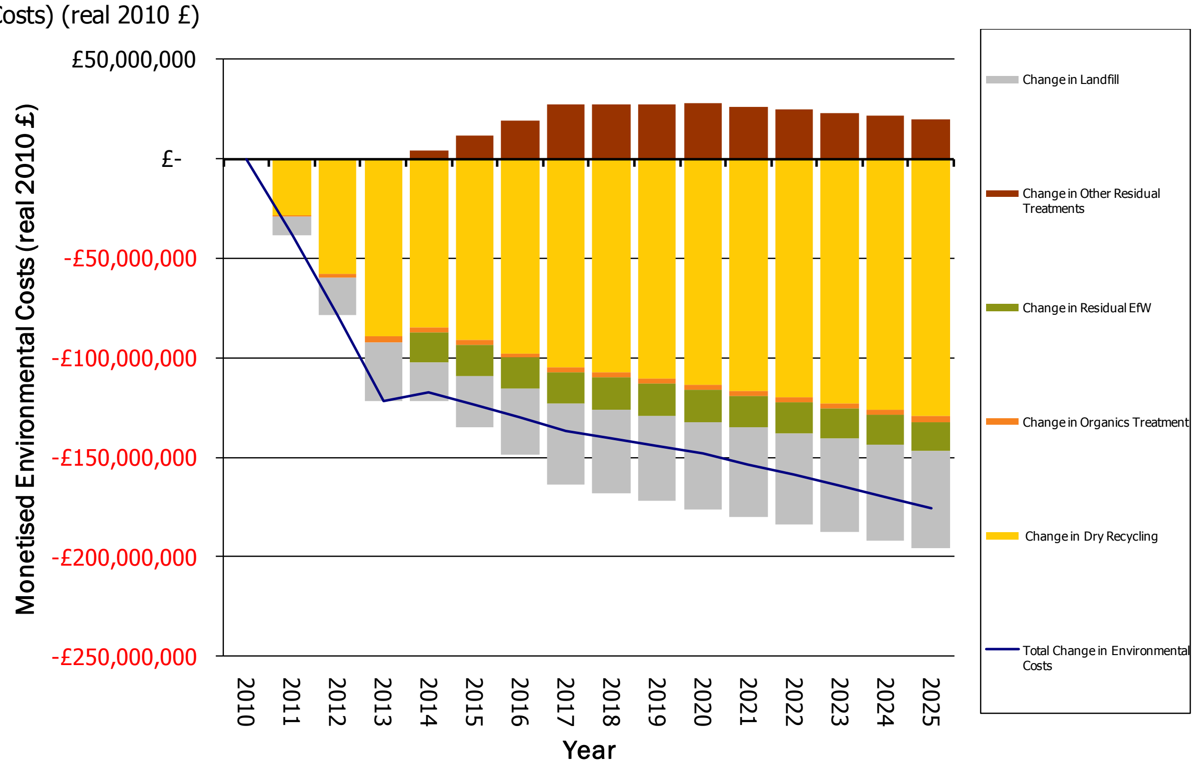


Figure 41: Environmental Costs of ZWP relative to BaU, Case with High Rationality in BaU (Central Treatment Costs) (real 2010 £)



7.3. Sensitivity with Respect to Residual Waste Treatment Costs

As discussed in Section 4.5.1, the Central Case assumes that the costs of non-landfill residual waste treatment is £88 per tonne in real 2010 terms, or the same as the cost of landfilling once the tax reaches £80 per tonne in nominal terms. Sensitivity analysis was conducted for the Cases where:

1. Non-landfill residual waste treatment costs were Low (£77 per tonne); and
2. Non-landfill residual waste treatment costs were High (£93 per tonne).

These analyses were conducted for the Central Rationality Case (with the requirement to sort introduced in 2013 and the requirement to pre-treat waste introduced in 2017).

The results are summarised in Table 29 whilst they are shown diagrammatically in Figure 42 to Figure 47. The key observations are as follows:

1. Where Treatment Costs are Low, then the recycling rate achieved in the BaU Scenario is lower than in the Central Case (since, as described in Section 6.2.3, the 'avoided costs of residual waste treatment / disposal' are no longer those of landfill. This means that there is more non-landfill residual waste treatment in the BaU Scenario than in the Central Case (though not as much as is required under ZWP). It also means that switching to ZWP implies a greater additional quantity of recycling and composting / digestion. The net effect of these changes is that the costs fall, and the environmental benefits increase;
2. Where Treatment Costs are High, then the recycling rates in BaU are as in the Central Case. The principle change, therefore, is that the switch away from landfill as a result of the requirement to pre-treat waste costs more. The savings from the switch to ZWP are, therefore, lower than in the Central Case, though they are still greater than zero. The environmental consequences change very little. The main effect is a small change owing to the fact that of the waste switched away from landfill under the High treatment cost Scenario, a higher proportion is dealt with through recycling and a slightly lower proportion through residual waste treatment. This means that the scope for additional environmental benefit is marginally lower in the High Treatment Case than in the Central Case.

Table 29: Net Present Value of the Change in Financial and Environmental Costs (from BAU to ZWP), 2010-2025, Variants in Residual Waste Treatment Cost (real 2010 £)

Case	**NPV of Financial Costs (2010-2025)**	**NPV of Environmental Costs (2010-2025)**
Low Cost (Low T, Cent R)	-£265 million	-£1,732 million
Central (Cent T, Cent R)	-£178 million	-£1,544 million
High Cost (High T, Cent R)	-£109 million	-£1,524 million

These changes are clearly of some significance. On the one hand, lower residual waste treatment costs reduce the financial costs of the ZWP relative to BaU as compared with the Central Case, and, because there is less recycling under BaU when treatment costs are low, the environmental impact of the switch to ZWP is much greater. The environmental consequences appear greater than the financial ones.

Where treatment costs are High, then because landfill remains the benchmark for the avoided cost of residual waste management, there is no additional scope for improved recycling rates (the economic drivers for recycling remain the same). However, the costs increase.

Figure 42: Financial Costs of ZWP relative to BaU, Case with Low Treatment Cost (Central Rationality) (real 2010 £)

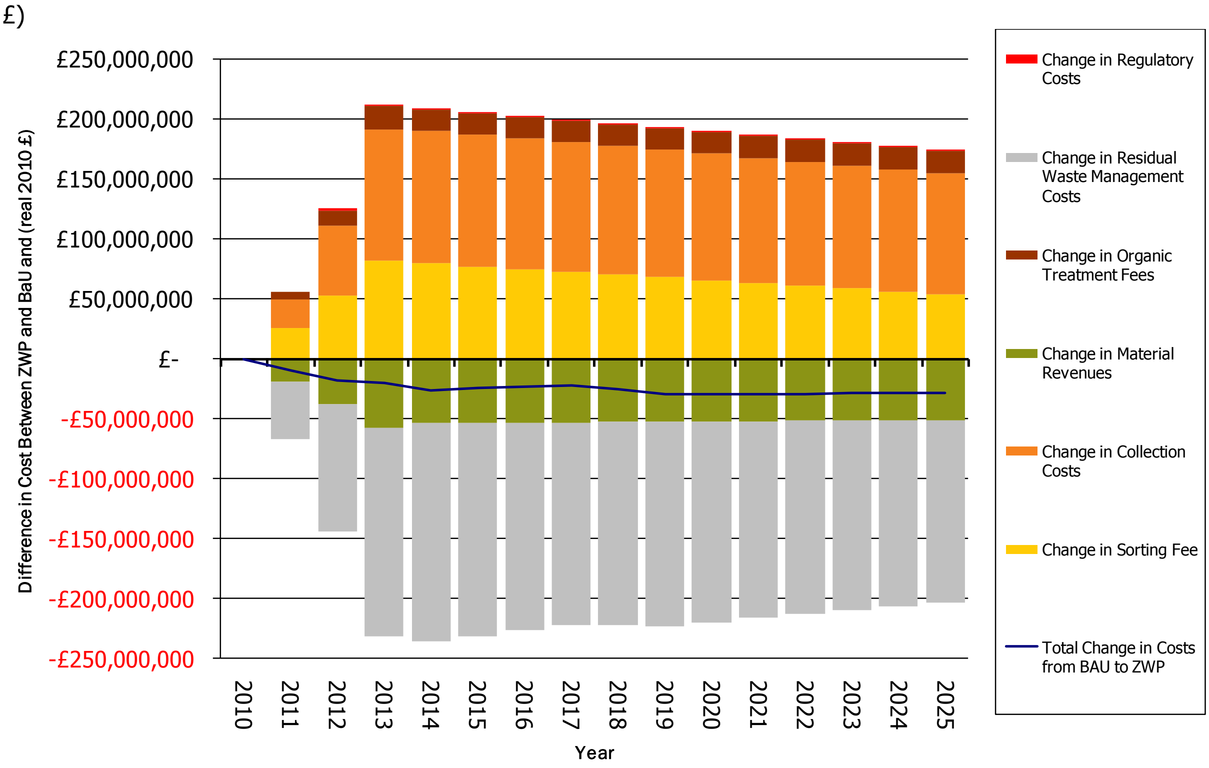


Figure 43: Financial Costs of ZWP relative to BaU, Case with High Treatment Cost (Central Rationality) (real 2010 £)

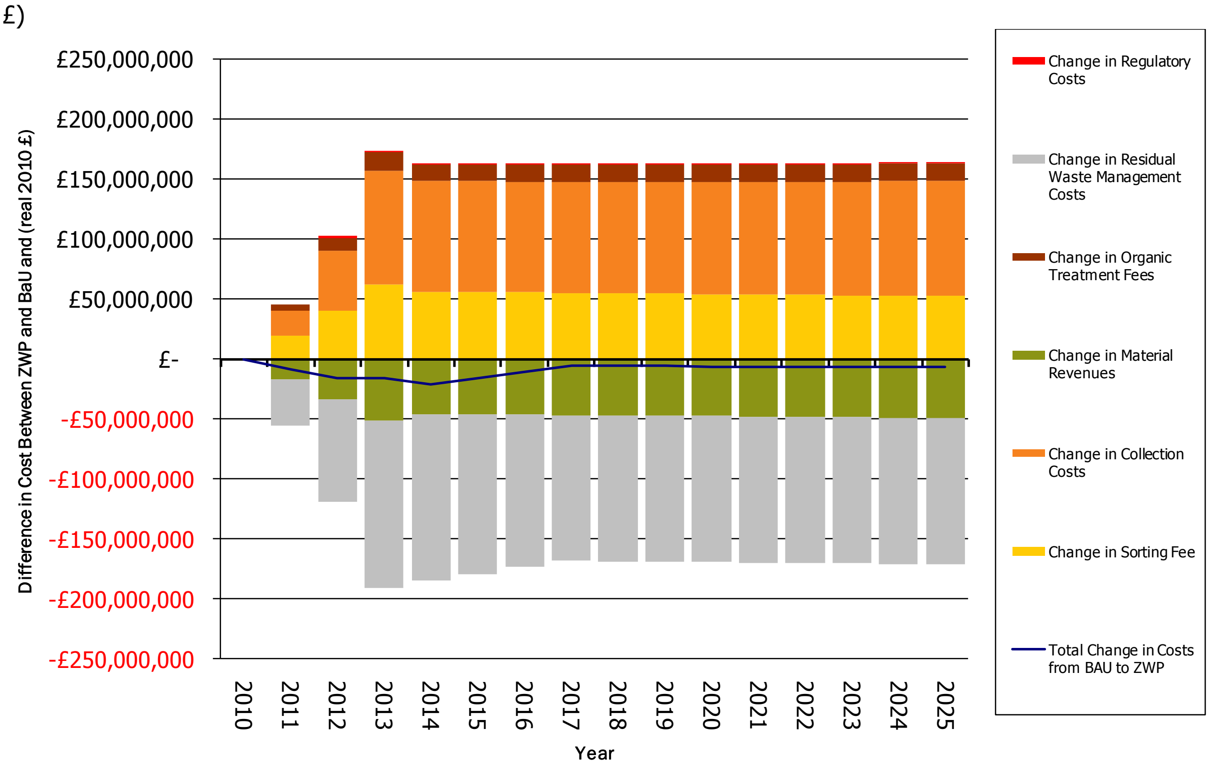


Figure 44: Financial Costs of ZWP relative to BaU, Case with Low Treatment Costs (Central Rationality), Sectoral Split (real 2010 £)

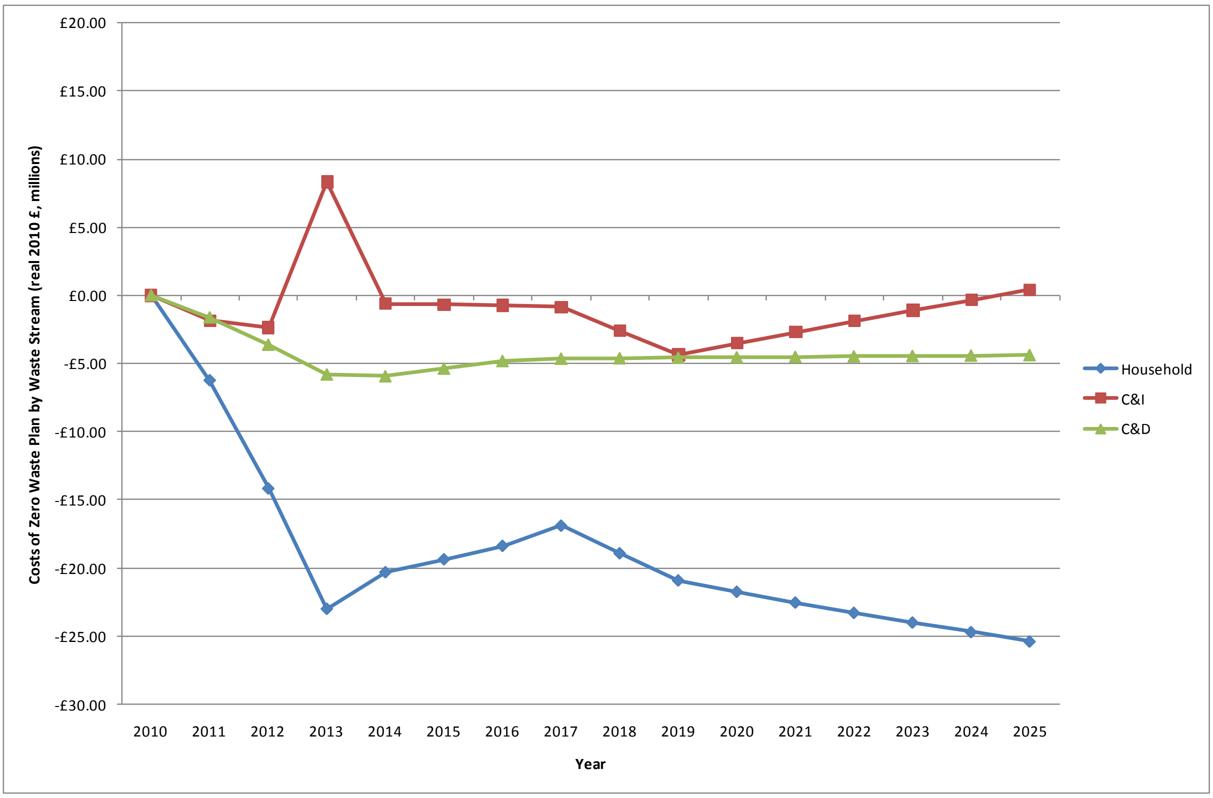


Figure 45: Financial Costs of ZWP relative to BaU, Case with High Treatment Costs (Central Rationality), Sectoral Split (real 2010 £)

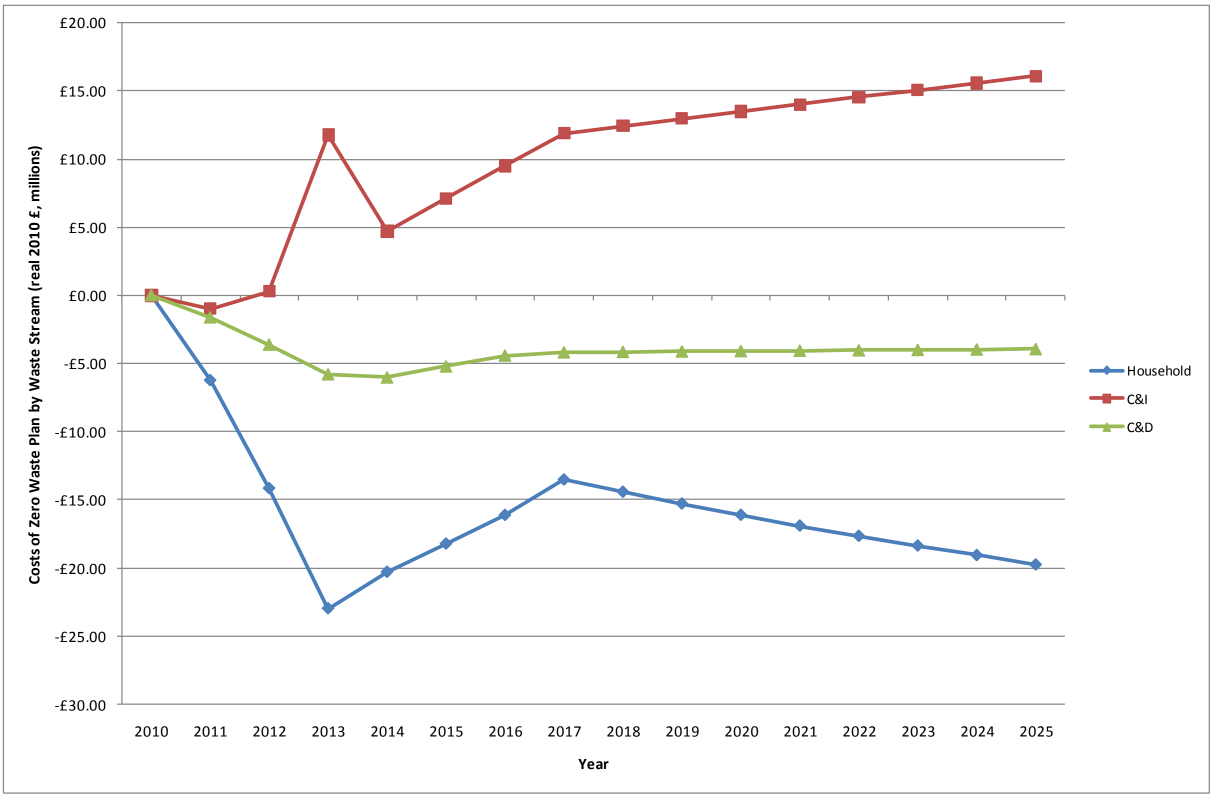


Figure 46: Environmental Costs of ZWP relative to BaU, Case with Low Treatment Costs (Central Rationality) (real 2010 £)

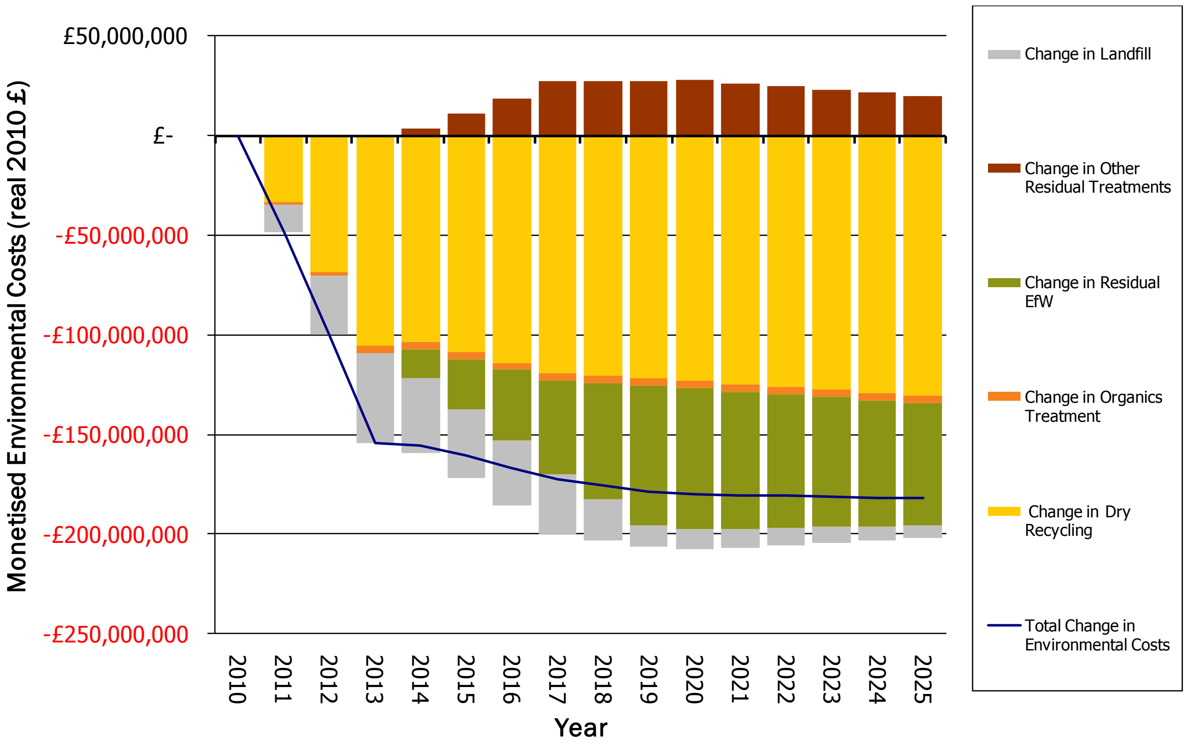
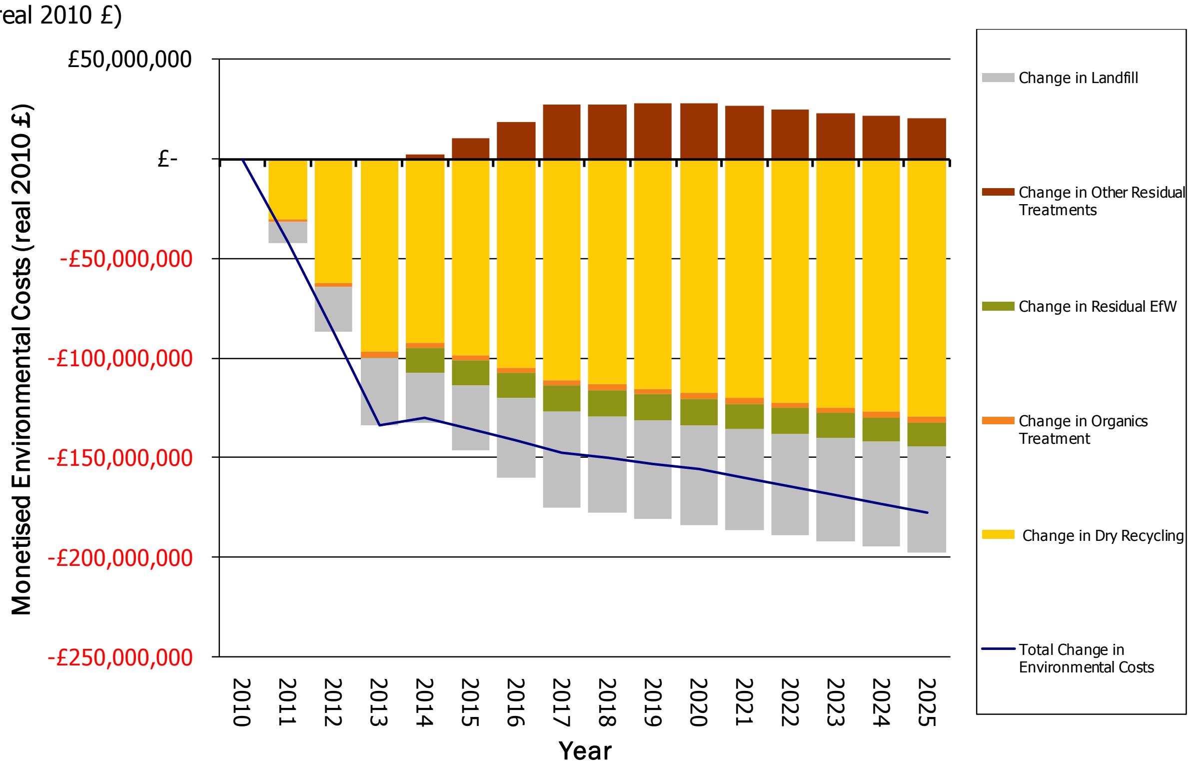


Figure 47: Environmental Costs of ZWP relative to BaU, Case with High Treatment Costs (Central Rationality) (real 2010 £)



7.4. Summary

This Section has highlighted the potential for the results of the analysis to vary considerably depending upon the timing of the ZWP Regulations' introduction, on exactly what happens in the residual waste treatment market, and on the extent to which the market for commercial and industrial waste recycling is 'rational' to begin with in the BAU scenario..

As regards sensitivity to the timing of the Regulations, then the basic message which emerges is that as the Requirement to Sort moves further back in time, so the financial savings increase, but the environmental benefits are diminished by a greater amount. The effects of moving the Requirement to Pre-treat are smaller, and the changes in the financial and environmental costs are more closely aligned.

As regards the assumption about the rationality of the response of the C&I waste market to the landfill tax, then in general, the less rational is the response to the landfill tax under BaU, then the greater the benefits (financial and environmental) of the ZWP become.

As regards the costs of residual waste treatment, once these fall below landfill, the recycling performance under BaU is diminished. This means that the lower the treatment costs are, then the greater is the benefit (financial and environmental) of the ZWP. Higher treatment costs simply add costs with no significant impact on performance.

8. Conclusions

The report has sought to estimate the costs and benefits of the ZWP relative to BaU for Scotland. It is worth emphasising that, in some instances, the data available has been of relatively poor quality and it has been difficult to generate a dataset which exhibits consistency with various sources available.. This does mean that the results need to be taken as indicative in their magnitude, not least because of uncertainties in the quantities of waste in the C&I and C&D sectors..

The Central Case is the one where:

1. There is a 'moderately rational' response to the landfill tax in the BAU scenario;
2. The costs of non-landfill residual waste treatment are the same as the costs of landfilling once the tax has reached £80 per tonne in nominal terms; and
3. A requirement to sort dry recyclables and food is introduced in 2013, and a requirement to pre-treat waste is introduced in 2017.

The headline results are as follows:

1. The financial benefits of the ZWP over and above BaU are of the order £18 million per annum once the ZWP has taken full effect; and
2. The environmental benefits are of the order £180 million once the ZWP has taken full effect.

The Net Present Value of the financial savings and the environmental benefits over the whole period are £178 million and £1.544 billion, respectively.

Key observations are offered below.

8.1. Financial Costs

For the waste stream as a whole, there are net savings generated. Because, in the Central Case, we have assumed that the costs of residual waste treatment are the same as for landfill from 2014, the switch in waste away from landfill and into other residual waste treatments is, by and large, cost neutral. Additional recycling under the requirement to sort key dry recyclables and food, however, delivers net financial savings. These are most significant for the household waste stream, but there are some savings associated with the C&D stream also. It should be recalled that these savings are being considered against a backdrop of an £80 (nominal) landfill tax.

The ZWP implies the need for around £1.16 billion in terms of capital investment over the fifteen year period examined. This is an increase of around £472 million relative to BaU. For local authorities, the effect is to increase the requirement for capital infrastructure, or access to such infrastructure (local authorities do not need to fund the capital investment directly, and may use revenue spend to access / support the investment in facilities) from around £140 million to £490 million over the fifteen year period.

8.2. Environmental Benefits

As would be expected, the ZWP delivers environmental benefits over and above those from BaU. These additional environmental benefits are of the order £180 million. The key contributing elements are:

1. The increase in recycling of dry recyclables;
2. The avoidance of landfill; and
3. The increase in organic waste treatment.

8.3. Sensitivity Analysis, Timing in the Central Case

As regards sensitivity to the timing of the Regulations, then the basic message which emerges is that as the Requirement to Sort moves further back in time, so the financial savings increase, but the environmental benefits are diminished by a greater amount. The effects of moving the Requirement to Pre-treat are smaller, and the changes in the financial and environmental costs are more closely aligned.

8.4. Sensitivity Analysis, Rationality and Treatment Cost

Five different cases – regarding residual waste treatment costs and rationality – were examined. These, and their associated financial and environmental costs (expressed in net present value terms), are set out in Table 30.

As regards the assumption about the rationality of the response of the C&I waste market to the landfill tax, then in general, the less rational is the response to the landfill tax under BaU, then the greater the benefits (financial and environmental) of the ZWP become.

As regards the costs of residual waste treatment, once these fall below landfill, the recycling performance under BaU is diminished. This means that the lower the treatment costs are, then the greater is the benefit (financial and environmental) of the ZWP. Higher treatment costs simply add costs with no significant impact on performance.

Table 30: Sets of Paired Assumptions Used in Modelling Switch from BaU to ZWP

	Low T	**Cent T**	**High T**
Low R		Cent T, Low R Financial -£185 million Environmental -£1,589 million	
Cent R	Low T, Cent R Financial -£265 million Environmental -£1,732 million	Cent T, Cent R **Central Case** Financial -£178 million Environmental -£1,544 million	High T, Cent R Financial -£109 million Environmental -£1,524 million
High R		Cent T, High R Financial -£123 million Environmental -£1,432 million	

8.5. Additional Comments

The following comments are offered concerning issues faced in the project and the desirability for further investigations:

1. There are some areas of the analysis which would merit further investigation. Knowing what we do about the available data and information, it would seem sensible to consider some further analysis – including survey work - of the commercial waste collection market in Scotland itself;
2. Regarding household waste, the modelling is 'top down' at present. Different authorities have different plans, and will likely take different approaches to achieving their targets. The study has sought to reflect, as far as possible, what local authorities may do, based upon information regarding their current collection schemes. Without deeper knowledge of their likely approach, however, the results remain indicative of likely costs. It should also be noted that the modelling represents efficiently functioning systems. Our extensive experience in England suggests there may be existing inefficiencies that can be squeezed out so as to limit any increases in collection costs implied by the ZWP; and
3. It would be interesting to conduct the analysis in a more conventional cost-benefit framework, enabling the environmental and financial costs to be added together. The approach taken here to assessing the financial costs, seeks to represent the actual costs that actors will face in the market, but thereby makes the combination of environmental and financial impacts problematic, from a methodological point of view.

Appendix 1 – Baseline Mass-flows

This Appendix outlines the baseline assumptions used to calculate the mass-flows from which the costs and benefits of the policies are derived. The baselines were constructed in relation to four key waste streams:

1. Household;
2. Commercial;
3. Industrial; and
4. Construction and Demolition.

These main assumptions required for each of the sectors are outlined in the following sections. These are:

1. Waste generation;
2. Waste composition; and
3. Waste management.

For consistency a standard composition was used for each sector. Thus any data sources were adjusted to be consistent with these categories:

- Paper and card
- Dense plastic
- Plastic film
- Glass
- Ferrous metal
- Non-ferrous metal
- Textiles
- Wood
- Food waste
- Green waste
- Furniture
- WEEE
- Other
- Incinerator Ash
- Soil
- Aggregate
- Insulation & Gypsum based materials
- Hazardous site waste

1. Household Waste

The total household waste arising in Scotland in 2008/09, from SEPA Waste Data Digest 10, was reported as 2,905,584 tonnes of waste. This was the most recent data available at the time the baselines were being constructed. The household waste stream was split into two distinct parts for the modelling of recycling a) kerbside collected and b) bring sites and HWRCs. Thus compositions and estimates of the total waste generated for each sub-waste stream were required. The compositions were derived from the most recent WasteWorks and AEA compositional analysis of household waste in Scotland in 2009. However, it was not possible to breakdown the recycling and composting element of this composition for our study. Therefore, the following approach was taken:

1. Use the WasteWorks compositions for:
    a. Kerbside residual;
    b. HWRC residual;
    c. Litter; and
    d. Bulky waste

and add back the quantities of recycling collected at the kerbside in 2008/09 to the kerbside residual composition to obtain the Total Kerbside Composition, and the other recycling to the HWRC residual, litter and bulky composition, to obtain the Bring Composition.[84]

However, the material specific recycling data in the Waste Data Digests is aggregated (in other words is the total for Scotland only) so the data by material and source for each Local Authority was extracted from WasteDataFlow. In addition trade waste had to be removed from the figures, as this will be included under the C&I waste stream. Some assumptions were also required to translate the data into the standard composition used in the model.

- Organic waste recycled from Table 11 of the Waste Data Digest 10 is 12.4% of the total waste arising, so we assume this is composed of 7% food waste and 93% garden waste to calculate the food and garden waste recycling rates. This proportion is based on our detailed understanding of the composting market in Scotland in order to calibrate the model to provide recycling rates for food and garden waste at around 5% and 80% respectively.
- For mixed cans the proportions of ferrous and non-ferrous were set at 70% and 30% respectively, and for other scrap metals at 90% and 10% respectively.

The following table shows the calculations including the % recycling from the kerbside and bring for each material (taken from WasteDataFlow). Note that some secondary recycling from incinerators, MBT and other treatments is included in the calculations, so as this is not double counted in the calculation of the compositions.

Table 31: Calculation of Material Based Recycling from Kerbside and Bring Sources

	Total Recycling: WDD 10	**Household Recycling (Less trade)**	**Kerbside Recycling, %**	**Bring Recycling, %**	**Secondary Recycling, %**	**Kerbside Recycling, tonnes**	**Bring Recycling, tonnes**
Paper and card	259,961	244,825	74%	26%	0%	181,520	63,305
Dense plastic	16,996	16,006	70%	30%	0%	11,252	4,755
Plastic film	0	0	70%	30%	0%	-	-
Glass	102,102	96,157	31%	69%	0%	29,908	66,249
Ferrous metal	37,988	35,777	20%	80%	0%	7,044	28,732
Non-ferrous metal	6,269	5,904	45%	55%	0%	2,681	3,222
Textiles	16,957	15,970	10%	90%	0%	1,618	14,352
Wood	67,773	63,827	0%	100%	0%	164	63,663
Food waste	25,290	25,290	77%	23%	0%	19,561	5,729
Green waste	335,999	335,999	69%	31%	0%	233,099	102,899
Furniture	19,268	18,146	19%	81%	0%	3,534	14,612
WEEE	18,586	17,504	0%	100%	0%	-	17,504
Other	58,271	54,878	30%	40%	29%	16,692	22,103
Incinerator Ash	10,919	10,283	0%	0%	100%	-	-
Soil	0	0	0%	0%	0%	-	-
Aggregate	99,269	93,489	0%	100%	0%	-	93,489
Insulation & Gypsum based materials	0	0	0%	0%	0%	-	-
Hazardous site waste	0	0	0%	0%	0%	-	-
Total	1,075,648	1,034,055				507,075	500,614

[84] *Note 'Bring' includes bring sites / banks and HWRCs.*

The final two columns were then added back to the non-recycled material calculated from the WasteWorks compositions and the total waste generation. The resulting waste compositions for the two modelled waste streams (Kerbside and Bring (inc. HWRC)) are as follows:

Table 32: Household Waste Compositions

Waste Fraction	Kerbside Composition	Bring (inc. HWRC) Composition
Paper and card	21%	11%
Dense plastic	8%	4%
Plastic film	3%	1%
Glass	6%	9%
Ferrous metal	3%	5%
Non-ferrous metal	1%	1%
Textiles	3%	4%
Wood	1%	11%
Food waste	25%	2%
Green waste	14%	14%
Furniture	0%	8%
WEEE	1%	6%
Other	13%	10%
Incinerator Ash	0%	0%
Soil	0%	0%
Aggregate	2%	14%
Insulation & Gypsum based materials	0%	0%
Hazardous site waste	0%	0%
Total	100.00%	100.00%

The current management of household waste was taken from a couple of sources. In terms of the recycling, the material specific data was captured from WasteDataFlow (See final two columns in Table 31). For residual treatment the total figure for incineration in 2008/09 was taken from Waste Data Digest 10, Table 3. The reporting of the Dumfries and Galloway MBT plant appeared to be split across a number of categories (i.e. the outputs of the process were reported not the total input). Thus the input capacity (60,000 tpa) was added onto the quantity incinerated.

2. Commercial and Industrial Waste

Data on the generation of commercial and industrial waste in Scotland can be obtained from the Business Waste Surveys and projections made in the Waste Data Digests. The latest survey was carried out in 2009 and the report published in April 2011.[85] The data is reported in calendar years, but the model was set up to calculate based upon the financial year. Thus some adjustment from one to the other was required. The calculation used is as follows:

FYn/n+1 = 0.75 x CYn + (CYn+1 x 0.25)

where FY = Financial Year and CY = Calendar Year.

The calendar year and financial year figures are shown in the tables below. Note to calculate 2009/10 the generation of waste in 2010 was assumed to be the same as in 2009.

[85] *WRc plc (2011) Statistical Analysis of Scotland Business Waste Survey Data for 2009, Final Report for SEPA, March 2011, see* http://www.sepa.org.uk/waste/waste_data/commercial__industrial_waste/business_waste_surveys.aspx

Table 33: C&I Waste Generation – Calendar Years

Calendar Year	2008	2009	2010
Tonnes Industrial	2,189,993	1,818,343	1,805,614
Tonnes Commercial	5,750,161	4,747,214	4,747,214

Table 34: C&I Waste Generation – Financial Years

Financial Year	2008/09	2009/10
Tonnes Industrial	2,097,080	1,815,161
Tonnes Commercial	5,499,424	4,747,214

When it comes to the composition of commercial and industrial waste, especially down to useable categories (i.e. not large proportions of 'mixed waste' or the like), there is very limited data available. One of the more detailed studies was carried out in Wales in 2007.[86] However, this still had a large proportion of mixed waste landfilled, thus missing the inclusion of various key materials in the total composition. A further study was carried out by SLR, which sought to measure the composition of mixed residual C&I waste.[87] This composition was applied to the quantity of 'mixed waste' landfilled reported in the Welsh survey in order to disaggregate it. The disaggregated tonnages were then added back to the waste reused, recycled and recovered to calculate the total composition of C&I waste.

Table 35: Composition of Mixed C&I Waste Landfilled in Wales (2007)

Waste Fraction	Industrial	Commercial
Paper and card	35%	36%
Dense plastic	10%	8%
Plastic film	8%	7%
Glass	1%	5%
Ferrous metal	5%	3%
Non-ferrous metal	1%	1%
Textiles	1%	1%
Wood	5%	5%
Food waste	11%	20%
Green waste	0%	1%
Furniture	0%	0%
WEEE	0%	1%
Other	23%	13%
Combustion Residues	0%	0%
Soil	0%	0%
Aggregate	0%	0%
Insulation & Gypsum based materials	0%	0%
Hazardous site waste	0%	0%

Source: SLR (2007) Determination of the Biodegradability of Mixed Industrial and Commercial Waste Landfilled in Wales and EA (2007) Industrial and Commercial Waste Arisings in Wales

[86] *Urban Mines (2007) Industrial and Commercial Waste Survey in Wales, Report for WAG*

[87] *SLR (2007) Determination of the Biodegradability of Mixed Industrial and Commercial Waste Landfilled in Wales and EA (2007) Industrial and Commercial Waste Arisings in Wales*

Table 36: Calculated Compositions for Commercial and Industrial Waste Streams

Waste Fraction	Industrial	Commercial
Paper and card	10.9%	41.1%
Dense plastic	3.7%	6.5%
Plastic film	1.2%	4.1%
Glass	1.8%	6.5%
Ferrous metal	10.5%	4.5%
Non-ferrous metal	4.3%	1.7%
Textiles	0.3%	0.9%
Wood	6.1%	4.3%
Food waste	15.0%	12.0%
Green waste	4.8%	1.8%
Furniture	0.0%	0.2%
WEEE	0.2%	1.2%
Other	16.3%	15.1%
Combustion Residues	20.4%	0.0%
Soil	0.7%	0.0%
Aggregate	3.7%	0.0%
Insulation & Gypsum based materials	0.0%	0.0%
Hazardous site waste	0.0%	0.0%

Table 36 shows the compositions that were calculated in the manner described above. In terms of the management of C&I wastes, reuse, recycling and recovery rates, on a material specific basis, were taken from the Wales Survey (Table 37). The main residual treatment for C&I waste was assumed to be incineration. Management rates were set so that the resulting tonnage of waste treated, was equivalent to the known business waste treatment capacity in Scotland (total Scottish capacity less household treatment). Incineration rates for the C&I sectors were thus set at around 4 to 5%.

Table 37: Reuse, Recycling and Recovery Rates for Commercial and Industrial Waste Streams

Waste Fraction	Industrial	Commercial
Paper and card	49%	49%
Dense plastic	58%	32%
Plastic film	0%	0%
Glass	92%	55%
Ferrous metal	90%	62%
Non-ferrous metal	93%	70%
Textiles	28%	22%
Wood	83%	31%
Food waste	88%	4%
Green waste	97%	48%
Furniture	0%	0%
WEEE	27%	52%
Other	53%	33%
Combustion Residues	43%	0%
Soil	0%	0%
Aggregate	0%	0%
Insulation & Gypsum based materials	0%	0%
Hazardous site waste	0%	0%
Total	**63%**	**38%**

3. Construction and Demolition Waste

Data on the generation of construction and demolition wastes was taken from SEPA data supplied to Eunomia. Waste arisings are estimated by SEPA from operator data returns. Due to legislative requirements of the Revised Waste Framework Directive, C&D recycling rates must be calculated without the inclusion of hazardous waste or naturally occurring wastes. The relevant article describes the position as such:

> *"by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be increased to a minimum of 70% by weight"*

Therefore, the total waste generated must also be calculated accordingly. When all wastes are considered, the total generation in 2008 was 8,633,219 tonnes, and in-line with the WFD 4,340,576 tonnes.

Again, the composition or management of C&D wastes, on a material specific level, is not well understood. The most detailed national survey was carried out in Wales in 2005/06.[88] This was the study used to calculate the rates, which could be applied to the total generation figures previously discussed. However, the composition estimated in this study had to be adjusted to reflect the removal of hazardous and naturally occurring wastes. This is not a straightforward task as the category 'Aggregate' includes an unknown proportion of naturally occurring material, such as sand and stones (EWC code 17.05.04), but also manufactured aggregates such as concrete, bricks and tarmac. The process to derive the correct total C&D composition was therefore as follows:

1. Adjust categories of waste from Wales survey to match the standard composition;
2. Remove 'soils' (all naturally occurring) and 'Hazardous' wastes from the composition;
3. Factor down the proportion of 'Aggregates' so that the calculated proportion between all wastes and waste less Haz and 17.05.04, was the same as the proportion between the generation figures noted above for Scotland (circa 2:1 or waste less Haz and 17.05.04 is around 50% of the total).

The calculated composition of C&D waste (less Haz and 17.05.04) is shown in Table 38.

One can see that, notwithstanding the exclusion of a large quantity of naturally occurring inert material, there is still a large proportion of dense aggregate type material in the waste stream. Other 'active' wastes are a much less significant proportion of the C&D waste stream.

The main management routes in the C&D sector are reuse (on- or off-site) recycling, treatment, incineration and landfill. However, the use of treatment and incineration is small (less than 1%). Thus most of the non-landfill management is reuse and recycling. Reuse and recycling rates were taken from the Welsh study and factored down so that the calculated landfill quantities were benchmarked against the quantities landfilled reported by site operators under EWC Chapter 17 (Construction and demolition wastes). The final reuse and recycling rates are also shown in Table 38.

[88] *Environment Agency (accessed 2010) Building the future 2005-06: A survey on the arising and management of construction and demolition waste in Wales 2005-06*

Table 38: Calculated Composition and Reuse / Recycling Rates for Construction and Demolition Waste Stream

Waste Fraction	Composition	Reuse and Recycling Rate
Paper and card	1%	20%
Dense plastic	2%	18%
Plastic film	0%	0%
Glass	0%	43%
Ferrous metal	2%	86%
Non-ferrous metal	1%	86%
Textiles	0%	0%
Wood	7%	72%
Food waste	0%	0%
Green waste	2%	46%
Furniture	0%	0%
WEEE	0%	18%
Other	3%	14%
Combustion Residues	0%	0%
Soil	0%	0%
Aggregate	79%	98%
Insulation & Gypsum based materials	3%	18%
Hazardous site waste	0%	0%

4. Quantities Landfilled

From the data and analysis undertaken for each waste stream it is possible, by material, calculate the total quantity landfilled. This is simply performed by multiplying the total waste generation by the total composition, subtracting the amount reused, recycled and recovered – to calculate the composition of residual waste – and subtracting the proportion of non-landfill treatment (such as incineration). To estimate the quantities of inert and active waste landfilled, each fraction, in the standard composition, was assigned to either type.

Table 39: Apportionment of Waste Types to Landfill Categories

Waste Fraction	Landfill
Aggregate	Inert
Dense plastic	Active
Ferrous metal	Active
Food waste	Active
Furniture	Active
Glass	Active
Green waste	Active
Hazardous site waste	Hazardous
Incinerator Ash	Inert
Insulation & Gypsum based materials	Inert
Non-ferrous metal	Active
Other	Active
Paper and card	Active
Plastic film	Active
Soil	Inert
Textiles	Active
WEEE	Active
Wood	Active

5. Maximum Recycling Rates under ZWP

Table 40: Maximum Household Recycling Rates under ZWP

Weight Based Recycling Rate	Recycling Rate under ZWP
Paper and card	85%
Dense plastic	45%
Plastic film	15%
Glass	90%
Ferrous metal	75%
Non-ferrous metal	75%
Textiles	60%
Food waste	55%

Table 41: Maximum Commercial Recycling Rates under ZWP

Weight Based Recycling Rate	Recycling Rate under ZWP
Paper and card	92%
Dense plastic	67%
Plastic film	57%
Glass	90%
Ferrous metal	90%
Non-ferrous metal	90%
Textiles	81%
Food waste	70%

Table 42: Maximum Industrial Recycling Rates under ZWP

Weight Based Recycling Rate	Recycling Rate under ZWP
Paper and card	90%
Dense plastic	80%
Plastic film	50%
Glass	95%
Ferrous metal	92%
Non-ferrous metal	95%
Textiles	80%
Food waste	95%

Table 43: Maximum C&D Recycling Rates under ZWP

Weight Based Recycling Rate	Recycling Rate under ZWP
Paper and card	95%
Dense plastic	75%
Glass	90%
Ferrous metal	90%
Non-ferrous metal	95%

6. Baseline Projections

The following tables present the headline baseline mass-flows.

Table 44: Baseline Mass-flows – Household Waste, thousand tonnes

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BaU	**Total Generated**	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906
	Total Recycling / Reuse / Recovery	1,163	1,240	1,317	1,395	1,472	1,472	1,472	1,472	1,472	1,472	1,472	1,472	1,472	1,472	1,472	1,472
	Total Incineration Operational (2010)	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
	Total Incineration Proposed	0	0	0	0	451	451	451	451	451	451	451	451	451	451	451	451
	Total Other Non-Landfill Treatment	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	Total Landfill	1,628	1,550	1,473	1,396	867	867	867	867	867	867	867	867	867	867	867	867
ZWP	**Total Generated**	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906
	Total Recycling / Reuse / Recovery	1,163	1,358	1,553	1,748	1,760	1,766	1,772	1,778	1,784	1,790	1,796	1,802	1,808	1,814	1,820	1,826
	Total Incineration Operational (2010)	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
	Total Incineration Proposed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Other Non-Landfill Treatment	60	60	60	60	60	368	676	1,031	1,025	1,019	1,013	1,007	1,001	995	989	983
	Total Landfill	1,628	1,433	1,237	1,042	1,030	717	403	41	41	41	41	41	41	41	41	41

Table 45: Baseline Mass-flows – Commercial Waste, thousand tonnes

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BaU	**Total Generated**	4,747	4,795	4,891	5,037	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088
	Total Recycling / Reuse / Recovery	2,141	2,270	2,425	2,610	2,750	2,769	2,788	2,807	2,826	2,845	2,864	2,883	2,902	2,920	2,939	2,958
	Total Incineration Operational (2010)	182	184	188	193	195	195	195	195	195	195	195	195	195	195	195	195
	Total Incineration Proposed	0	0	0	0	159	159	159	159	159	159	159	159	159	159	159	159
	Total Other Non-Landfill Treatment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Landfill	2,424	2,341	2,278	2,234	1,983	1,964	1,945	1,926	1,907	1,888	1,869	1,850	1,832	1,813	1,794	1,775
ZWP	**Total Generated**	4,747	4,795	4,891	5,037	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088
	Total Recycling / Reuse / Recovery	2,141	2,673	3,246	3,880	3,952	3,952	3,952	3,952	3,952	3,952	3,952	3,952	3,952	3,952	3,952	3,952
	Total Incineration Operational (2010)	182	184	188	193	195	195	195	195	195	195	195	195	195	195	195	195
	Total Incineration Proposed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Other Non-Landfill Treatment	0	0	0	0	159	335	510	686	686	686	686	686	686	686	686	686
	Total Landfill	2,424	1,938	1,457	964	781	605	430	254	254	254	254	254	254	254	254	254

Table 46: Baseline Mass-flows – Industrial Waste, thousand tonnes

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BaU	**Total Generated**	1,815	1,833	1,870	1,926	1,965	1,951	1,937	1,924	1,910	1,897	1,884	1,870	1,857	1,844	1,831	1,819
	Total Recycling / Reuse / Recovery	1,172	1,191	1,223	1,269	1,303	1,294	1,284	1,275	1,267	1,258	1,249	1,240	1,231	1,223	1,214	1,206
	Total Incineration Operational (2010)	90	91	93	96	98	97	96	96	95	94	94	93	92	92	91	90
	Total Incineration Proposed	0	0	0	0	60	60	59	59	59	58	58	57	57	57	56	56
	Total Other Non-Landfill Treatment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Landfill	553	551	554	562	504	501	497	494	490	487	483	480	477	473	470	467
ZWP	**Total Generated**	1,815	1,833	1,870	1,926	1,965	1,951	1,937	1,924	1,910	1,897	1,884	1,870	1,857	1,844	1,831	1,819
	Total Recycling / Reuse / Recovery	1,172	1,226	1,294	1,378	1,408	1,398	1,389	1,379	1,369	1,360	1,350	1,341	1,331	1,322	1,313	1,304
	Total Incineration Operational (2010)	90	91	93	96	98	97	96	96	95	94	94	93	92	92	91	90
	Total Incineration Proposed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Other Non-Landfill Treatment	0	0	0	0	60	159	257	353	350	348	346	343	341	338	336	334
	Total Landfill	553	516	483	452	398	296	195	96	96	95	94	94	93	92	92	91

Table 47: Baseline Mass-flows – C&D Waste (excluding Haz and 17.05.04), thousand tonnes

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BaU	**Total Generated**	4,256	4,227	4,197	4,168	4,138	4,109	4,081	4,052	4,024	3,996	3,968	3,940	3,912	3,885	3,858	3,831
	Total Recycling / Reuse / Recovery	3,773	3,763	3,752	3,742	3,732	3,705	3,679	3,654	3,628	3,603	3,578	3,552	3,528	3,503	3,478	3,454
	Total Incineration Operational (2010)	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6
	Total Incineration Proposed	0	0	0	0	31	31	31	31	31	30	30	30	30	30	29	29
	Total Other Non-Landfill Treatment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Landfill	476	457	437	419	368	366	363	361	358	356	353	351	348	346	343	341
ZWP	**Total Generated**	4,256	4,227	4,197	4,168	4,138	4,109	4,081	4,052	4,024	3,996	3,968	3,940	3,912	3,885	3,858	3,831
	Total Recycling / Reuse / Recovery	3,773	3,791	3,808	3,824	3,811	3,785	3,758	3,732	3,706	3,680	3,654	3,628	3,603	3,578	3,553	3,528
	Total Incineration Operational (2010)	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6
	Total Incineration Proposed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Other Non-Landfill Treatment	0	0	0	0	31	58	85	111	110	109	108	108	107	106	105	105
	Total Landfill	476	429	382	336	289	260	231	203	201	200	198	197	196	194	193	192

Table 48 Baseline Mass-flows – Total Waste, thousand tonnes

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BaU	**Total Generated**	13,724	13,760	13,863	14,037	14,096	14,054	14,011	13,969	13,927	13,886	13,844	13,803	13,763	13,722	13,682	13,642
	Total Recycling / Reuse / Recovery	8,248	8,464	8,718	9,016	9,256	9,240	9,224	9,208	9,193	9,177	9,162	9,147	9,133	9,118	9,104	9,090
	Total Incineration Operational (2010)	335	337	343	351	355	354	353	353	352	351	351	350	349	349	348	347
	Total Incineration Proposed	0	0	0	0	702	702	701	700	700	699	698	698	697	697	696	695
	Total Other Non-Landfill Treatment	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	Total Landfill	5,081	4,899	4,743	4,610	3,723	3,698	3,673	3,648	3,623	3,598	3,573	3,548	3,524	3,499	3,474	3,450
ZWP	**Total Generated**	13,724	13,760	13,863	14,037	14,096	14,054	14,011	13,969	13,927	13,886	13,844	13,803	13,763	13,722	13,682	13,642
	Total Recycling / Reuse / Recovery	8,248	9,047	9,901	10,830	10,932	10,902	10,871	10,841	10,811	10,782	10,753	10,724	10,695	10,666	10,638	10,610
	Total Incineration Operational (2010)	335	337	343	351	355	354	353	353	352	351	351	350	349	349	348	347
	Total Incineration Proposed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Other Non-Landfill Treatment	60	60	60	60	311	920	1,527	2,181	2,172	2,162	2,153	2,144	2,135	2,126	2,117	2,108
	Total Landfill	5,081	4,316	3,559	2,796	2,498	1,878	1,259	594	592	590	588	586	584	582	580	578

Appendix 2 - Description of 'Local Authority' Collection Cost Model

7. Overview

Eunomia Research & Consulting's Proprietary Waste Collection Cost Model, Hermes, is a sophisticated spreadsheet based tool that allows a wide range of variables to be accounted for, and which enables the optimisation of scenarios to accurately reflect local circumstances.

The recycling performance of each collection system scenario is built up by specifying a range of performance parameters for each component of the system. Performance parameters include weight and volume of material collected by current systems, residual composition, the materials targeted by each collection service, the number of households of each type (e.g. detached, semi-detached, terrace etc) that the service is available to, the participation rate of those households and the recognition rate achieved from those households for the materials targeted.

Costs are built up automatically by the model using unit cost data extracted from the database. The model calculates the numbers of vehicles, containers, and crew required and multiplies these by their unit costs. Disposal costs, net cost/income from material sales, are also calculated and included in the costings. Finally the model adds overheads for management and administration, depot costs, and insurances and financing. Although capital requirements are shown in the model, annual costs are based on the amortised cost of capital using depreciation periods and interest rates entered by the user.

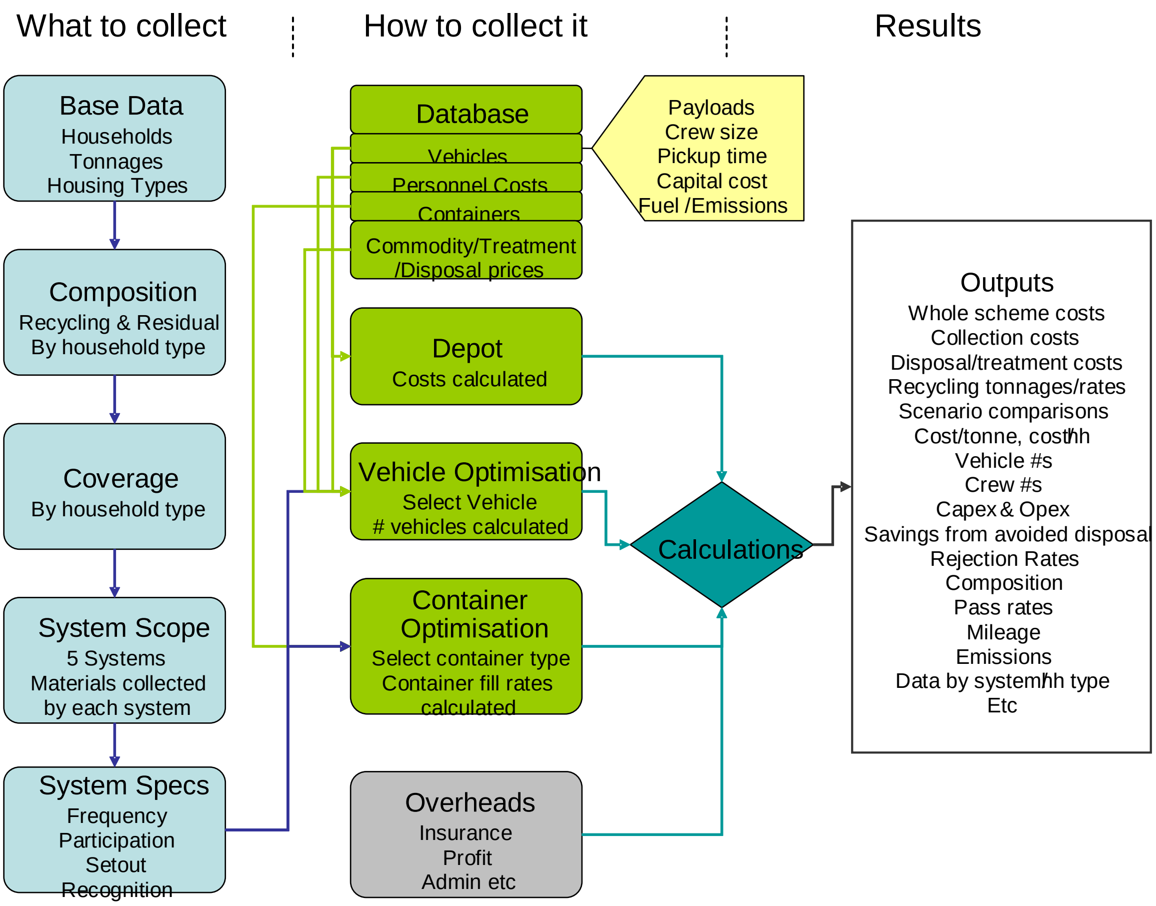
8. Model Detail

Figure 48 presents a simplified schematic of how the Eunomia Local Authority model calculates collection cost figures. This representation of the model divides the modelling into 3 key phases:

1. Determining what material is to be collected through what systems (blue boxes);
2. Determining the types of physical systems that will be used to undertake the collection (green boxes); and
3. Calculations and outputs.

A brief description of each of the modules in these three phases follows. Where the values used in the modelling are ubiquitous across all scenarios these are presented below.

Figure 48 Eunomia Collection Cost Model Schematic



8.1. Phase 1: Defining what to collect

8.1.1. Base Data

In this module key data related to the characteristics of the collection area to be modelled is entered. This includes the number of households to be collected from, the types of households (e.g. terraced, semi detached etc) and number of households of each type, and the total tonnages of material that will be handled by the collection system being modelled. This includes all collected residual material as well as the tonnages of material recycled and composted in the baseline system.

8.1.2. Composition

The proportion of each type of material that is in the waste stream and that can potentially be separately collected for recycling or composting is crucial data, as it determines the ultimate potential performance of systems being modelled. This module allows tailored composition information for up to 20 different material streams to be entered. In addition adjustment can be made for variations in composition by household type – for example flats will produce negligible quantities of garden waste while detached households will produce above average quantities. Composition data is then used in this module to determine quantities of each material available from each type of household.

8.1.3. Coverage

The proportion of each type of household covered by each element of the collection system (e.g. dry recycling, garden waste, residual waste) is then specified. This module then calculates the number of households that need to be serviced by each element of the collection system. Within this module travel distances for collection vehicles are also calculated based on the numbers of each type of household.

8.1.4. System Scope

Up to five different types of collection system (e.g. dry recycling, food waste, garden waste, residual waste etc) can be modelled simultaneously as an integrated system, with variations possible for each housing type (for example the dry recycling system for flats may collect different materials than for detached households), giving a total of 30 possible system combinations. In this module the types of material collected by each system combination is specified. This module then calculates the potential of each type of material that can be separately collected for recycling or composting.

8.1.5. System Specification

In this module the user specifies the frequency of each collection system, the participation rate of households (how many household use the service), the set-out rate (the proportion of household putting out material for collection each collection day), and the recognition rate for each type of material (how much of the recyclable material in each household actually gets put out for collection). This is then used to calculate how much material will actually be required to be collected by each of the separate systems (and hence the performance in terms of recycling rates etc, of each of the systems). These are key calculations and the assumptions behind them are based on a set of rules based on the performance of known system configurations.
Once this data has been calculated it is then possible to determine the best way to collect the available material.

8.2. Phase 2: Determining Collection Systems

8.2.1. Database

The database contains equipment specifications and cost and performance information, which is used in the model to calculate costs. Four key areas of information are contained in the model:

Vehicles & Crew

The database contains information on actual vehicles, their typical staffing configurations and their performance parameters including, payloads, capital costs, fuel use, emissions, running costs (e.g. maintenance, Road User Charges, insurance etc) and pickup times for each household. This information is used in the 'Vehicle Optimisation' module to calculate the numbers of vehicles required and the cost of those vehicles. The capital cost of vehicles is converted to annualised costs based on a vehicle replacement period, and finance costs.

Personnel Costs

Personnel costs for each grade of operative including supervisors and management are specified here. Once crew numbers and supervisor ratios etc are determined this information is used to calculate personnel costs of each system and total personnel costs.

Containers

A database of container types is maintained with key performance data including capacity, lifespan/replacement rate, and capital cost. This data is based on manufacturers' specifications and market prices for bulk purchasing.

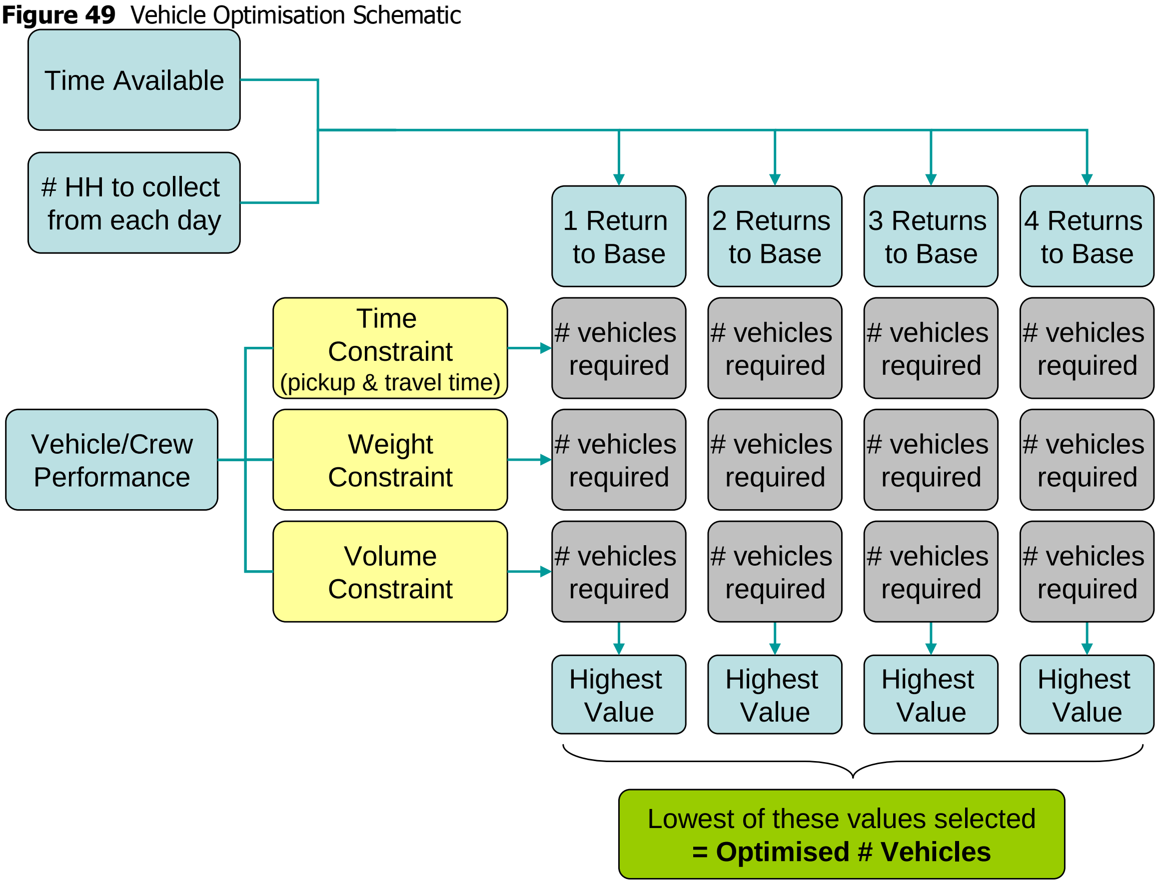
Commodity/Treatment/Disposal prices

The costs or income from collection of each material type is contained in the database. Costs can be updated to reflect actual contractual situations in a given authority. Costs are calculated as net costs after bulking and transport. Once the total quantity of each type of material separately collected is known this can be multiplied by the cost of processing that material (e.g. in the case of organic waste) or income from sale of that material (e.g. for dry recyclable commodities).

8.2.2. Vehicle Optimisation

This module is the heart of the collection cost model as it is here that the numbers of vehicles & crew required are calculated, which are the most significant elements of the total system cost. For the purposes of illustration **Figure 49** below shows the basis of the how vehicle numbers are calculated.

Figure 49 Vehicle Optimisation Schematic



There are 3 basic parameters that are used to determine the numbers of vehicles required: the time that is available to undertake collections, the number of households that need to be collected from, and the performance characteristics of the vehicles and crew.

1. The time available for actual collection is influenced by the number of times a vehicle must return to base to empty its load – the more times it has to return to base the less time it has available to be picking up from households.
2. Similarly the vehicle/crew performance is a function of how quickly they can pick up from each household (and travel time between households on a round), how quickly the vehicle reaches its weight limit, and how quickly it fills up in terms of volume. These factors will be influenced by the types of materials that are being collected.
3. For each vehicle configuration the model calculated the number of vehicles required if they were to return to base only once. It does this for the time constraint factor, the weight constraint factor and the volume constraint factor. The highest of these values (i.e. the most trucks) represents the constraining factor for the 1 return to base scenario. This is repeated for 2,3 & 4 returns to base yielding 4 values (i.e. numbers of trucks). The lowest of these 4 values is the optimum number of vehicles needed to collect the specified amount of material from the number of households in the time available.

The Vehicle Optimisation module calculates fractions of vehicles, as this captures the incremental changes between different types of systems. In practice fractions of vehicles would obviously not be used but this would be accounted for by using smaller vehicles and/or building in spare capacity. In addition it should be noted that the modelling is based average loads rather than peak loads. A slight redundancy factor is built into the model therefore to account for the effect of peak loads.

8.2.3. Container Optimisation

The container optimisation module calculates the number of containers required and their costs based on coverage of the systems and lifespan/replacement rates. It also provides a check on container volumes and fill ratios to ensure that sufficient containment capacity is being provided to householders.

8.2.4. Depot

A 'depot builder' is included where the configuration of the relevant depot or transfer stations can be specified. This is generally a fixed cost (i.e. it will not necessarily vary between systems). The depot builder takes account of personnel, maintenance, site based vehicles and machinery, as well as any site works and rentals that may be applicable.

8.2.5. Overheads

Overheads such as insurance costs, profit levels, management and administration, finance costs etc can be specified. In the local authority modelling the following values were specified:

- Overheads for all systems combined were set at approximately £350,000 per annum
- Profit margins were set at 5% of contract costs

8.3. Outputs

The model is extremely flexible in the outputs that are possible to be generated. Key output parameters include:

- Whole scheme costs
- Collection costs
- Disposal/treatment costs
- Recycling tonnages/rates
- Scenario comparisons
- Cost/tonne, cost/hh
- Vehicle numbers
- Crew numbers
- Capex & Opex
- Savings from avoided disposal
- Rejection Rates
- Composition
- Pass rates
- Mileage
- Emissions
- Data by system/hh type

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